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Clustering-Based Analysis of Public Complaint Patterns for Strengthening Digital Literacy and Educational Public Service Governance

Ifani Hariyanti, Tiara Anisa*

Universitas Adhirajasa Reswara Sanjaya, Bandung, Indonesia
*Correspondence: E-mail: 17212005@ars.ac.id

ABSTRACT

This study aimed to analyze patterns of public complaints using a clustering approach to strengthen digital literacy and improve the governance of educational public services. The method applied was the K-Means algorithm implemented with data preprocessing, transformation, and evaluation of optimal clusters using the elbow technique. The results revealed three meaningful clusters of complaints characterized by category, region, and reporting period. These findings are important because they show differences in dominant patterns of complaints, which highlight variations in participation and responsiveness. The outcomes imply that policy adjustments should focus on improving response quality in highly active areas and expanding awareness and literacy efforts in low-participation regions. This study contributes to educational contexts by demonstrating how clustering can be used to analyze feedback for better service delivery, thereby enhancing inclusivity, transparency, and trust in digital governance.

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1. INTRODUCTION

The advancement of digital technology has significantly reshaped governance and service delivery. Information and communication technology are increasingly integrated into administrative systems to ensure efficiency, transparency, and responsiveness in addressing public needs. In practice, however, the implementation of e-government often encounters challenges, including limited participation, insufficient responsiveness, and low levels of trust, which reduce its potential to strengthen accountability (Marzuki *et al*., 2023; Larasati & Citrawan, 2024).

Indonesia has adopted several digital service platforms to support governance and encourage public involvement. Despite these efforts, usage remains uneven across regions, revealing a persistent gap between the availability of digital services and their actual utilization. Many citizens are still reluctant to engage with digital platforms due to slow responses, lack of awareness, or inadequate accessibility. These weaknesses are visible not only in general public services but also in educational contexts, where effective complaint-handling mechanisms could improve responsiveness to the concerns of students, teachers, and parents (Gupitasari & Anwar, 2022; Wulandari, 2023; Yahya & Setiyono, 2022).

This study applies a clustering-based approach to analyze public complaint patterns with the aim of uncovering hidden structures in data that are not visible through conventional reporting. By using the K-Means algorithm, variations in complaint categories, reporting regions, and time periods can be identified and interpreted to guide policy formulation. The novelty of this research lies in linking data mining techniques with the enhancement of digital literacy and the governance of educational public services. The expected impact is to promote inclusivity, transparency, and trust by providing evidence-based recommendations that strengthen public engagement and service quality.

2. METHODS

2.1. Research Object

This study focused on public complaint report data collected from a centralized digital reporting system during the 2020-2024 period. The research applied a quantitative exploratory approach using secondary data officially obtained from the Department of Communication, Informatics, and Statistics of West Bandung Regency. The dataset initially contained 875 entries with eight attributes: report date, report classification, category, report type, report source, main agency, disposed agency, and subdistrict. After cleaning and selection, 665 entries were retained for analysis. From these, three key attributes (date, category, and district) were chosen because they provide essential information for identifying temporal and spatial patterns of public complaints (Utama, 2020).

2.2. Research Flow

The study followed the Input-Process-Output (IPO) model to guide the analysis.

2.2.1. Input

The input consisted of complaint report data obtained from the centralized reporting system. The original dataset was refined to include only valid entries that matched the study objectives. Non-urgent reports, such as aspirations, were excluded to maintain focus on complaints requiring immediate follow-up.

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2.2.2. Process

The process stage included data pre-processing, determination of the optimal number of clusters, and clustering implementation. Data pre-processing involved cleaning empty or erroneous entries, transforming dates into datetime format, and deriving new attributes such as month and year. Categorical attributes, including category and district, were transformed into numerical values through one-hot encoding to ensure compatibility with the K-Means algorithm.

Figure 1 is referenced at this stage because the elbow method was employed to determine the optimal number of clusters. The graph showed a steep decline in error values from one to two clusters, followed by a gradual decrease. The most significant inflection point occurred at three clusters, which was selected as the optimal solution for further analysis.

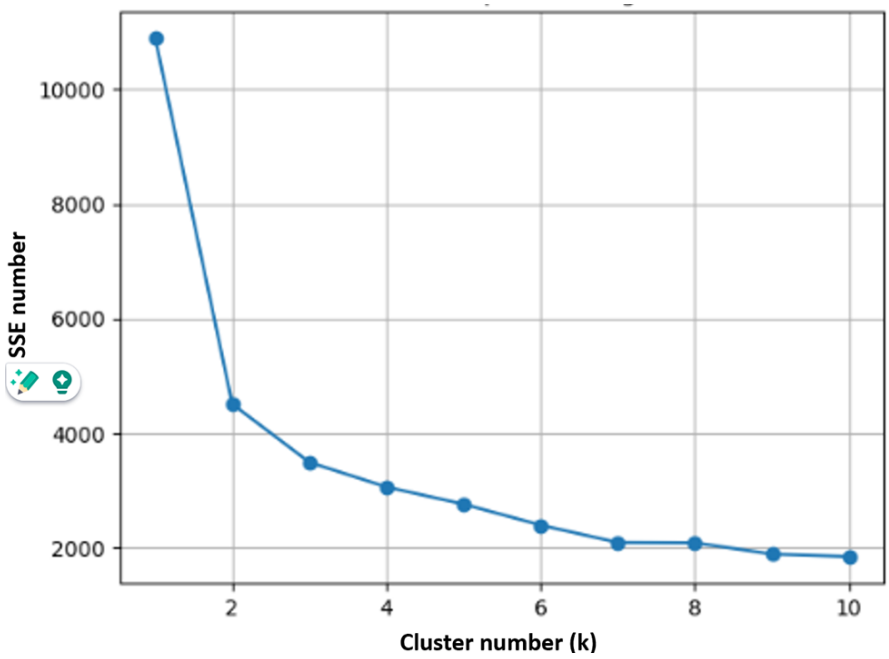

Figure 1. Elbow method results.

2.2.3. Output

The output included visualizations and interpretations of the clustering results. These outputs demonstrated how public complaints were distributed by category, region, and time. The visual representations were designed to provide insights into complaint patterns that could inform targeted and data-driven policymaking.

2.3. Research Tools and Materials

The analysis was conducted using a personal computer and the Google Colaboratory platform. Python version 3 was applied with several libraries: pandas for data manipulation, matplotlib.pyplot for visualization, and sklearn.cluster for clustering implementation. Additional libraries included sklearn.metrics for evaluating clustering performance and re for handling regular expressions. Microsoft Excel was used for the initial data review. The main material analyzed was the dataset of public complaint reports submitted from 2020 to 2024 (Hendrastuty, 2024).

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2.4. Pre-processing Data

The pre-processing phase ensured that the dataset was accurate and suitable for clustering. After removing incomplete and irrelevant entries, only complaint-type reports were retained. The coronavirus-related category was excluded because it was only present in a short period and did not represent the entire timeframe. Dates were transformed into attributes of month, year, and combined period for temporal analysis. Categorical variables were encoded into binary numerical columns using one-hot encoding to meet the numeric input requirement of the K-Means algorithm. This transformation produced a structured dataset capable of revealing hidden patterns (Anshori & Nuraini, 2020).

2.5. Optimal Cluster Determination

Figure 1 was used to identify the optimal number of clusters with the elbow method. The decline of error values slowed significantly after three clusters, indicating that this number provided the best balance between simplicity and accuracy. Therefore, the K-Means algorithm was applied with three clusters to generate meaningful classifications of complaint data.

3. RESULTS AND DISCUSSION

3.1. Results of the First Research Question: Can K-Means clustering uncovers patterns in public complaint data by category, region, and time (2020–2024)?

To begin the discussion, **Figure 2** is presented to illustrate the distribution of complaint categories within the first cluster.

Figure 2(a) indicates that Cluster 0 consists predominantly of high-volume complaints related to social issues, infrastructure, and other public services. These categories reveal the areas in which citizens most frequently raise concerns, particularly regarding drainage, road maintenance, and spatial planning. The dominance of these issues reflects recurring infrastructural challenges that directly affect daily life and community wellbeing. This pattern is consistent with earlier research suggesting that citizen complaints often converge around basic service delivery and infrastructural deficiencies, which tend to be highly visible and have immediate impacts on society (Wulandari, 2023). The fact that these reports are heavily concentrated in Cluster 0 highlights that infrastructure remains a pressing concern in the studied region.

The geographic dimension of Cluster 0 is represented in **Figure 2(b)**, which shows that the majority of reports originated from central districts. These areas are characterized by higher population density and relatively greater digital access, factors that contribute to more frequent use of digital reporting platforms. The concentration of complaints from central regions suggests a relationship between accessibility, awareness, and participation in digital governance systems. From a governance perspective, this distribution implies that central districts benefit more from opportunities to voice concerns, while peripheral areas remain less represented. This imbalance indicates the need for targeted strategies to strengthen participation in more remote communities, where infrastructural challenges may also be significant but remain underreported (Sabani *et al*., 2023).

The temporal pattern of Cluster 0 is shown in **Figure 2(c)**, which demonstrates that complaint activity tends to peak toward the end of each year. Several factors may explain this pattern. First, seasonal variations such as increased rainfall during certain months exacerbate drainage and flood-related problems, prompting citizens to submit complaints. Second, the end of the year often coincides with budget cycles and local government reporting schedules,

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which may influence the timing of both complaints and administrative responsiveness. This result highlights the interplay between environmental conditions, institutional practices, and citizen engagement. The seasonal spikes suggest that clustering is effective in revealing not only the type and location of problems but also the temporal dynamics that shape public service demands (Hendrastuty, 2024).

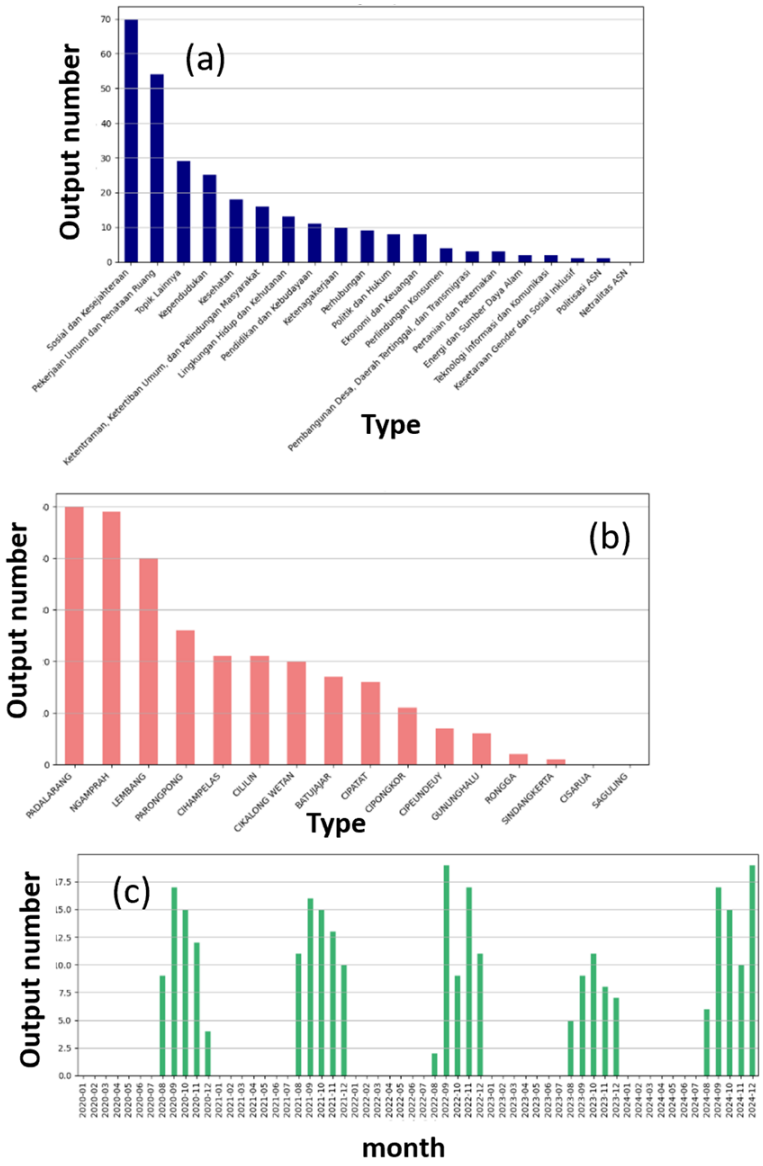

Figure 2. Results for cluster 0: (a) category, (b) district, and (c) time distribution.

In contrast to Cluster 0, Cluster 1 contains a much smaller number of reports, and the issues raised are less concentrated (**Figure 3**).

Figure 3(a) demonstrates that complaints in Cluster 1 are distributed across multiple categories, including infrastructure, social services, and population administration. The sporadic nature of these reports reflects citizen engagement that is reactive rather than continuous. For instance, complaints about administrative services such as identity cards or population data tend to arise in response to specific personal needs rather than recurring collective problems. This cluster highlights the variability of public engagement, which is influenced by situational factors and individual experiences of service delivery.

Geographically, Cluster 1 shows a more balanced distribution across central and peripheral districts, as presented in **Figure 3(b)**. Unlike Cluster 0, where reports were concentrated in

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more urbanized areas, Cluster 1 suggests that peripheral communities also engage in digital reporting, albeit at a lower frequency. This pattern underscores the potential for broader adoption of digital complaint platforms if awareness and accessibility barriers are addressed. Importantly, the presence of peripheral districts in this cluster highlights the necessity of ensuring inclusivity in digital governance. Without targeted efforts to improve connectivity and literacy, peripheral communities' risk being marginalized in public decision-making processes (Gupitasari & Anwar, 2022).

The temporal distribution of Cluster 1, presented in **Figure 3(c)**, indicates that complaints tend to emerge earlier in the year. This suggests that citizens may be motivated to raise issues at the beginning of administrative cycles, possibly in anticipation of new programs or budg*et a*llocations. Alternatively, this pattern may reflect the urgency of addressing problems carried over from the previous year. The relatively lower volume of reports in this cluster, however, demonstrates that citizen engagement is uneven, with peaks and troughs shaped by both external conditions and personal circumstances. Understanding this variability is crucial for designing outreach strategies that encourage more consistent participation throughout the year (Utama, 2020).

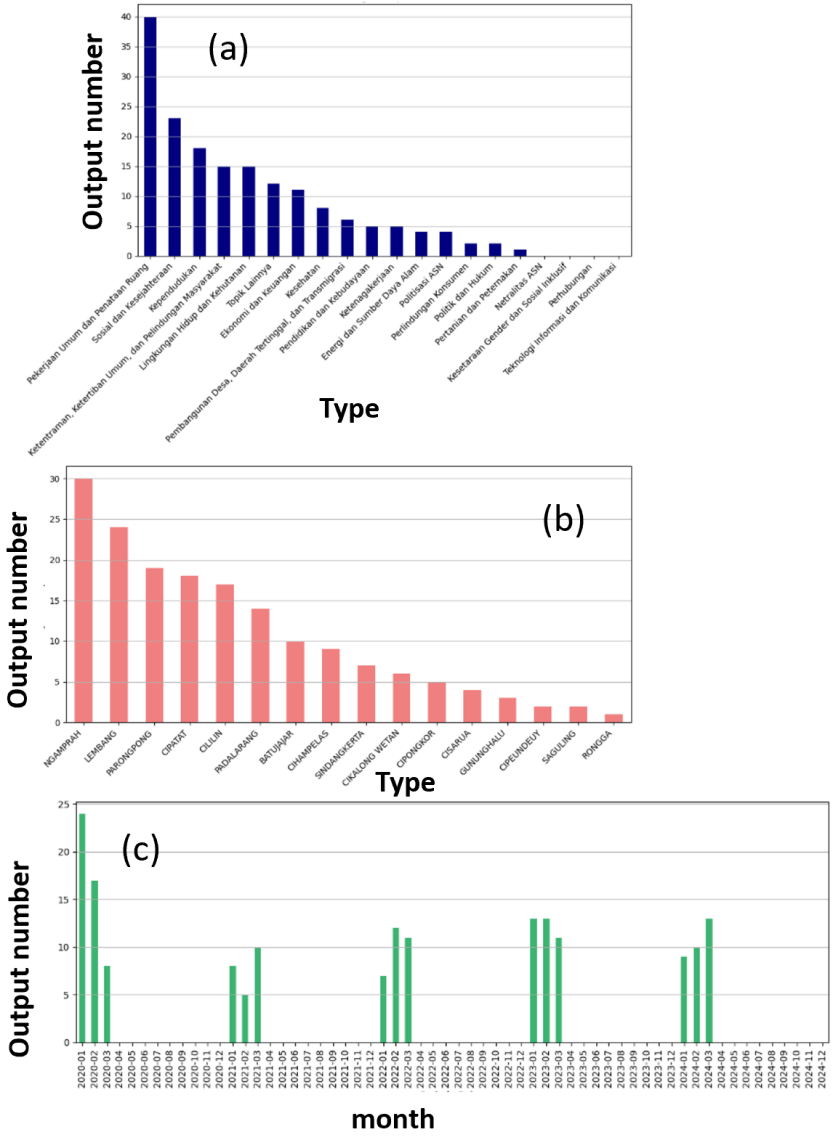

Figure 3. Results for cluster 1: (a) category, (b) district, and (c) time distribution

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Cluster 2 represents an intermediate pattern between Clusters 0 and 1 (**Figure 4**).

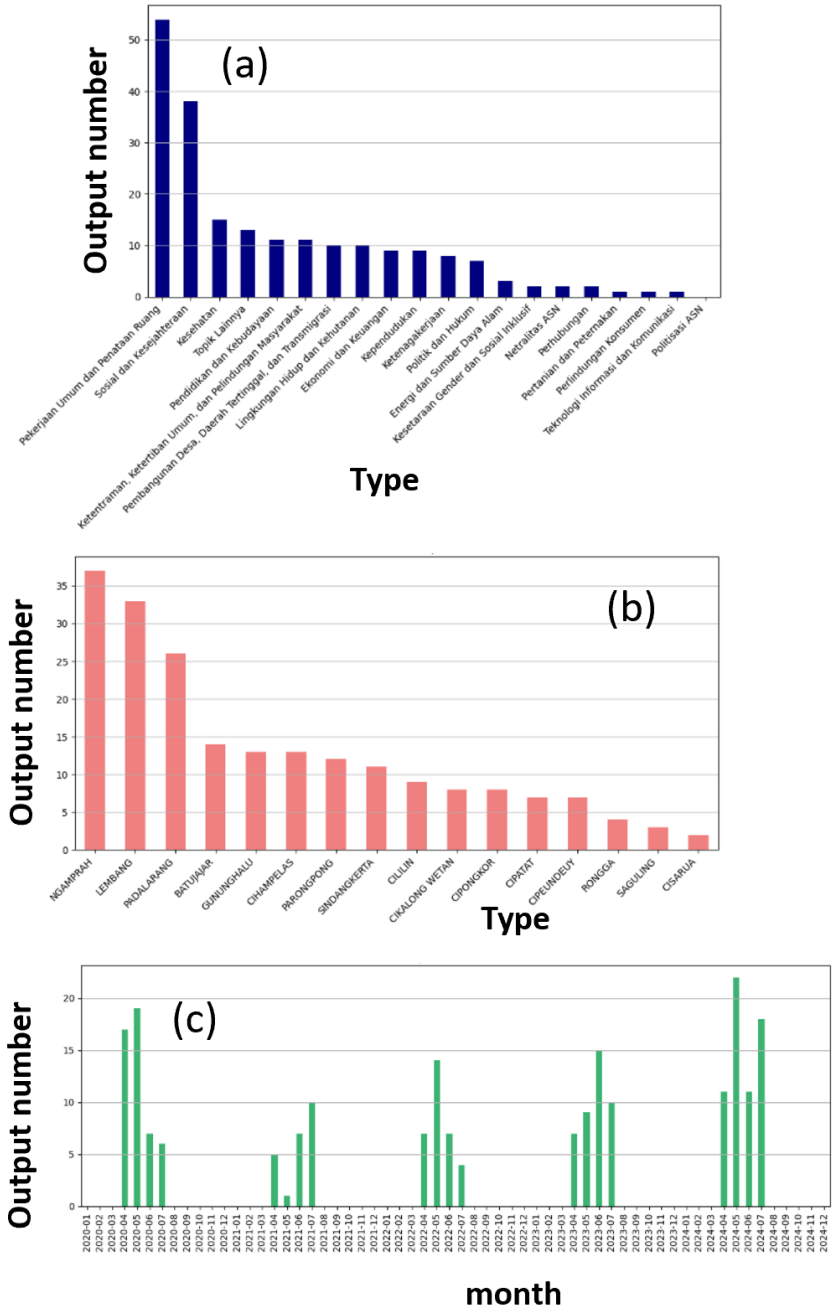

Figure 4. Results for cluster 2: (a) category, (b) district, and (c) time distribution

Figure 4(a) shows that complaints in Cluster 2 are moderately distributed across categories, with no single issue overwhelmingly dominating the cluster. This suggests that while certain problems such as infrastructure and administrative services remain significant, they do not reach the same intensity as observed in Cluster 0. The medium-level activity captured in this cluster reflects communities where issues exist but may not trigger widespread mobilization of complaints. This finding is important because it identifies areas where problems may be underreported yet still require attention from policymakers.

The regional distribution in Cluster 2, illustrated in **Figure 4(b)**, shows participation from both central and peripheral districts, though with varying intensities. This reflects a mix of urban and rural concerns, highlighting that while some communities engage more actively,

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others contribute sporadically. The ability of clustering to reveal this intermediate engagement pattern is valuable because it prevents policy focus from being skewed only toward the extremes of high or low reporting. Instead, Cluster 2 identifies regions where moderate participation could be nurtured into more sustained engagement through targeted educational and digital literacy initiatives (Marzuki *et al*., 2023).

The temporal distribution of Cluster 2, presented in **Figure 4(c)**, reveals that complaint activity peaks in the middle of the year. This contrasts with Cluster 0, where complaints rise at the end of the year, and Cluster 1, where they appear earlier. The mid-year peak may be linked to the implementation phase of local government programs, when citizens are more likely to notice gaps or shortcomings in service delivery. This temporal pattern emphasizes the value of clustering analysis because it uncovers distinct cycles of citizen engagement that might otherwise remain hidden. Recognizing such cycles allows policymakers to align interventions with periods of heightened citizen awareness, thereby improving responsiveness and trust.

The three clusters together demonstrate that K-Means analysis effectively identifies diverse complaint patterns by category, region, and time. Cluster 0 highlights high-volume reports concentrated in central areas with seasonal peaks, Cluster 1 reflects sporadic and low-volume engagement spread across different regions, and Cluster 2 represents medium-level reporting with mid-year peaks. These findings provide a multidimensional understanding of citizen engagement that surpasses the descriptive statistics usually offered in public data summaries. Importantly, the results underscore that digital complaint platforms are not merely channels of expression but also valuable sources of knowledge for understanding the dynamics of public needs (Anshori & Nuraini, 2020).

3.2. Results of the Second Research Question: How can clustering results guide government strategies to improve digital complaint services?

To begin the discussion, **Figure 5** is presented to illustrate the regional distribution mapping of complaint reports across districts. **Figure 5** shows that certain districts such as Ngamprah, Lembang, and Padalarang recorded the highest frequency of complaints. These areas are generally more urbanized, with higher levels of internet penetration and digital literacy. The high reporting rate indicates greater citizen awareness of the complaint platform, as well as the presence of recurring issues that compel communities to report consistently. However, the same finding also implies that these districts place greater demands on government responsiveness. Without sufficient capacity to respond quickly, the backlog of complaints can erode trust, even in areas where citizen engagement is strong. This highlights the dual challenge of managing both volume and quality in digital complaint services (Marzuki *et al*., 2023).

Conversely, districts such as Saguling, Cisarua, and Rongga demonstrated minimal participation in the reporting system. The low level of engagement suggests barriers such as limited digital access, inadequate awareness campaigns, or low levels of digital literacy. These findings are critical because they demonstrate that the digital divide not only influences educational outcomes but also shapes civic participation in governance. When certain communities are excluded from digital reporting systems, their voices remain unheard, which perpetuates inequalities in service delivery. Addressing these gaps requires a combination of technical, educational, and social strategies to foster equitable participation (Sabani *et al*., 2023).

The clustering analysis provides actionable insights for policymaking. For high-reporting districts, the primary strategy should focus on enhancing response quality. This includes

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reducing the average response time, increasing transparency in follow-up processes, and adopting monitoring dashboards that allow real-time updates on complaint handling. By improving the speed and clarity of responses, governments can sustain citizen trust and encourage continued participation. In education, similar approaches could be applied in universities or schools, where student feedback mechanisms must be supported by timely and transparent follow-up to build confidence in institutional responsiveness (Wulandari, 2023).

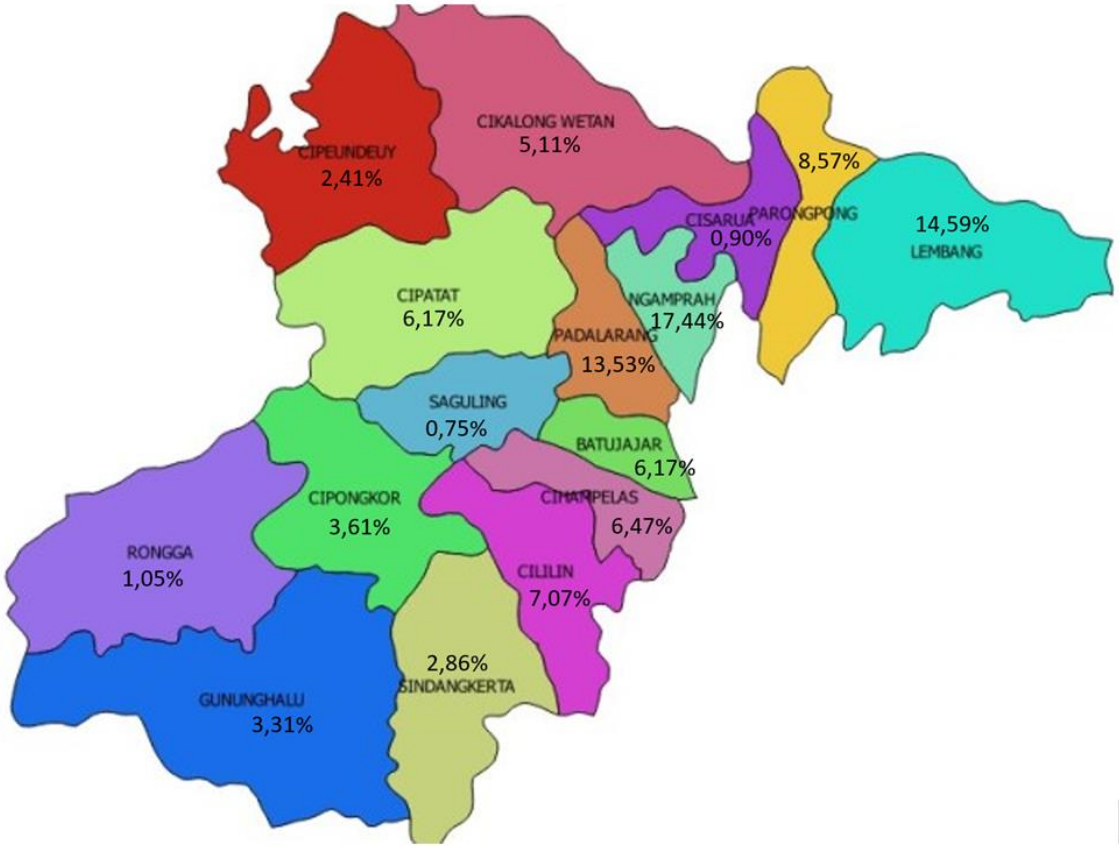

Figure 5. Visualization of regional distribution mapping.

For low-participation districts, strategies should emphasize accessibility and awareness. Educational campaigns on digital literacy could empower communities to use online reporting systems effectively. For instance, workshops, training sessions, and collaboration with schools could introduce students and parents to the importance of participating in digital governance. By integrating digital complaint literacy into educational contexts, young generations can act as catalysts for broader community participation. This approach is consistent with the broader goal of fostering inclusive governance, where all citizens, regardless of location or background, can contribute to the improvement of public services (Gupitasari & Anwar, 2022).

The medium-participation regions identified in Cluster 2 also offer important lessons. These regions represent communities where engagement exists but has not yet reached its full potential. Policymakers could adopt targeted interventions to convert moderate engagement into sustained participation. For example, feedback loops that visibly demonstrate how complaints lead to tangible changes could encourage communities to remain active. In the educational domain, this strategy can be mirrored by ensuring that student evaluations and suggestions are not only collected but also acted upon, with

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outcomes communicated back to stakeholders. Such feedback mechanisms build a culture of trust and accountability, which is essential for strengthening governance (Utama, 2020).

Another important implication of the clustering results is the role of temporal patterns in guiding resource allocation. Since Cluster 0 peaked at the end of the year, government agencies can anticipate increased workloads during this period and allocate additional resources accordingly. Similarly, the mid-year peaks of Cluster 2 suggest that monitoring and intervention should be intensified during program implementation cycles. By aligning resources with identified temporal patterns, governments can optimize efficiency and avoid delays. In education, the same principle can be applied by aligning support services with critical academic periods, such as exam seasons or enrollment phases, when student feedback and complaints are more likely to rise (Hendrastuty, 2024).

The broader discussion emphasizes the importance of integrating data-driven approaches into governance. Traditional methods of evaluating complaint systems often rely on descriptive summaries that overlook deeper patterns. Clustering, however, reveals multidimensional dynamics that combine category, region, and time. These insights enable a more nuanced understanding of public service needs, leading to more targeted and effective policies. From an educational perspective, adopting similar clustering methods to analyze student or staff feedback could uncover hidden patterns of concern, such as peak periods of stress, recurrent administrative issues, or uneven participation across departments. This demonstrates the transferability of the methodology beyond governance into education.

Furthermore, the findings highlight the significance of digital literacy as both a prerequisite and an outcome of effective complaint systems. On the one hand, digital literacy enables citizens to access, navigate, and utilize platforms for reporting. On the other hand, participation itself reinforces digital literacy by providing opportunities for practice and engagement. This reciprocal relationship suggests that governments should not only promote digital literacy as a standalone policy goal but also design services that function as practical tools for strengthening these skills. Educational institutions can play a central role in this effort by embedding digital governance modules into curricula, thereby preparing students to become active participants in civic life while simultaneously enhancing their technological competencies (Larasati & Citrawan, 2024).

Clustering results also have implications for equity in service delivery. Without targeted interventions, digital platforms risk reinforcing existing disparities by privileging communities with higher digital access. High-reporting districts may receive more attention simply because they are more visible in the data, while low-reporting districts remain marginalized. The identification of clusters mitigates this risk by highlighting underrepresented regions and ensuring that they are not overlooked in policymaking. This aligns with the principles of inclusive governance, which emphasize that public services should be designed to reach all citizens, not only those who are digitally active. In education, this principle translates into ensuring that feedback systems are accessible to all students, including those with limited access to technology or with special needs (Anshori & Nuraini, 2020).

The practical applications of clustering extend further into the development of monitoring dashboards. By visualizing complaint patterns in real time, dashboards can support proactive decision-making. For instance, sudden spikes in complaints related to specific categories could trigger immediate investigations and interventions. In an educational setting, dashboards could be used to track student concerns across semesters, helping administrators identify and address systemic issues such as curriculum overload or inadequate facilities. Such tools not only improve responsiveness but also enhance transparency, as stakeholders can

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observe the status of complaints and the progress of solutions. Transparency, in turn, builds trust and strengthens the legitimacy of institutions (Sabani *et al*., 2023).

In summary, the second research question demonstrates that clustering results provide a strong foundation for strategic decision-making. High-reporting areas require improved quality of responses, low-participation regions need targeted digital literacy initiatives, and medium-engagement communities offer opportunities for capacity building. Temporal patterns inform resource allocation, while clustering insights promote inclusivity, transparency, and accountability. Beyond governance, these findings carry direct relevance for education, where similar methods can be applied to enhance service delivery and stakeholder satisfaction. The results confirm that data mining is not merely a technical exercise but a strategic tool that bridges digital governance and educational service improvement.

3.3. Broader Interpretation of Clustering Results

The findings from the clustering analysis not only highlight complaint patterns but also provide a foundation for reflecting on how digital platforms function as tools for governance. The three identified clusters—high-volume, sporadic, and medium-level reporting each reveal different forms of citizen engagement. These differences are important because they show that public participation is not homogeneous. Instead, it varies across categories, geography, and time, and is influenced by social, cultural, and institutional factors. Understanding these variations is critical for designing policies that respond not only to the content of complaints but also to the dynamics of participation itself (Marzuki *et al*., 2023).

The dominance of infrastructure-related complaints in Cluster 0 reflects persistent challenges in the provision of basic public services. Roads, drainage, and spatial planning are foundational to community wellbeing, and failures in these areas are immediately visible and disruptive. From a policy standpoint, the prominence of these issues suggests that citizens are motivated to report when problems have tangible and direct effects on daily life. This is consistent with findings in previous studies that demonstrated how infrastructural shortcomings are among the most frequently reported issues in many regions because they are easily perceived and have immediate consequences (Wulandari, 2023). The implication for governance is that visible services must be prioritized in response strategies, as failure to do so undermines public trust in government effectiveness.

The sporadic pattern in Cluster 1 provides a different insight. Complaints in this cluster were often related to population administration and social services, which are typically associated with individual needs. Unlike infrastructure issues that affect large groups simultaneously, administrative concerns arise in specific contexts, such as applying for identity cards or accessing health benefits. This highlights the role of personal motivation in digital participation. When services are critical to individual welfare, even in low-engagement communities, citizens are likely to interact with digital platforms. This demonstrates that the scope of digital governance must be broad enough to accommodate both collective and individual concerns. It also suggests that personalized services and responsive feedback mechanisms are essential for sustaining participation at the individual level (Sabani *et al*., 2023).

The intermediate engagement reflected in Cluster 2 emphasizes the importance of recognizing communities that fall between extremes. These areas may not generate large volumes of complaints, but their moderate participation suggests potential for growth if proper incentives are provided. For example, visible government action in response to complaints could encourage citizens in these regions to continue engaging with the system.

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This indicates that participation is not static but can be cultivated through appropriate policies and practices. In education, similar dynamics exist, where moderate levels of student feedback can be increased if institutions actively demonstrate that input is valued and leads to improvements in learning environments (Utama, 2020).

Temporal variations also provide key insights. The end-of-year peaks in Cluster 0 demonstrate how seasonal conditions, such as heavy rainfall, interact with infrastructural deficiencies to produce surges in complaints. This finding emphasizes the importance of aligning governance strategies with environmental and temporal realities. Governments can plan ahead by reinforcing services during high-risk periods, such as rainy seasons, to preempt the issues most likely to trigger complaints. The early-year activity in Cluster 1 suggests that administrative and social services may be more relevant at the start of the year, possibly linked to program renewals or budg*et al*locations. Meanwhile, the mid-year peaks in Cluster 2 highlight the significance of monitoring during program implementation cycles. Together, these temporal dynamics illustrate that digital governance cannot adopt a uniform approach throughout the year; it must be adaptive and responsive to specific cycles of demand (Hendrastuty, 2024).

The geographic distribution of complaints also reveals disparities in digital access and literacy. High-reporting districts were concentrated in central areas with better infrastructure, while peripheral districts reported less frequently. This reflects the digital divide, where unequal access to technology results in unequal representation in governance. Without deliberate intervention, this disparity risks reinforcing systemic inequalities, as regions with higher digital literacy and better connectivity dominate the policymaking agenda. From an educational perspective, this finding underscores the need to integrate digital literacy programs into schools and universities, particularly in underserved areas. By equipping young people with the skills to use digital platforms effectively, education can play a crucial role in bridging the gap between urban and peripheral communities (Gupitasari & Anwar, 2022).

The integration of clustering analysis into policymaking represents a move toward evidence-based governance. Traditional monitoring methods often summarize complaints in terms of frequency but fail to reveal deeper structures. Clustering, by contrast, allows policymakers to see beyond raw numbers and understand the multidimensional patterns that shape citizen engagement. This method enhances the capacity of institutions to allocate resources strategically, anticipate seasonal peaks, and ensure equitable attention across regions. Such evidence-based approaches also improve accountability, as they demonstrate that policies are grounded in data rather than assumptions. In the educational sector, evidence-based decision-making is equally important. Schools and universities increasingly collect feedback from students, but unless this feedback is systematically analyzed, opportunities for improvement may be overlooked. Clustering can reveal patterns of concern that traditional analysis misses, thereby strengthening institutional responsiveness (Larasati & Citrawan, 2024).

The discussion also highlights the reciprocal relationship between digital governance and digital literacy. Effective complaint systems require citizens to be able to navigate platforms, articulate concerns, and monitor responses. At the same time, regular use of such systems enhances digital literacy by giving citizens opportunities to practice digital engagement. This creates a feedback loop in which participation both depends on and contributes to digital literacy. Recognizing this relationship is important for policymakers, who should design systems that are user-friendly and educational in nature. In education, this principle aligns with pedagogical approaches that integrate practical digital tasks into learning. For example,

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encouraging students to use institutional reporting tools not only improves administrative services but also strengthens digital competencies that are transferable to broader civic engagement (Sabani *et al*., 2023).

Another key implication of the clustering results is the importance of equity in digital service design. If systems are designed only with highly engaged communities in mind, they risk excluding marginalized populations. Clustering reveals underrepresented groups, ensuring that they are not overlooked in decision-making. This principle resonates strongly with the goals of inclusive education, where policies must be tailored to meet the diverse needs of students. Just as governments must address disparities in complaint reporting, educational institutions must ensure that all students, including those with limited access to technology, can participate fully in institutional processes. The alignment of these principles underscores the relevance of clustering as a tool for promoting inclusivity across sectors (Anshori & Nuraini, 2020).

The development of visualization tools, such as dashboards, also emerges as a practical application of clustering. Dashboards provide real-time insights into complaint patterns, enabling proactive responses. They also enhance transparency by allowing citizens to monitor the progress of their complaints. This visibility builds trust, as it demonstrates that reports are not simply collected but actively acted upon. In education, dashboards can similarly be used to track student concerns, making the process of institutional feedback more transparent. For instance, if multiple students report issues with a particular course or facility, administrators can quickly identify and address the problem. By making data visible and actionable, dashboards strengthen the connection between reporting and improvement, both in governance and in education (Wulandari, 2023).

Finally, the clustering analysis reinforces the importance of adopting multidimensional perspectives in understanding public participation. Complaints are not isolated events but are embedded within social, temporal, and spatial contexts. Clustering allows researchers and policymakers to account for these dimensions simultaneously, producing insights that are richer and more actionable. This holistic approach aligns with contemporary educational paradigms that emphasize interconnected learning, where multiple factors are considered in analyzing student outcomes. In both governance and education, adopting multidimensional approaches leads to more nuanced understanding and more effective interventions (Larasati & Citrawan, 2024).

3.4. Integrating Findings into Governance and Education

The clustering results provide not only technical insights but also broader implications for how digital governance and educational service systems can be improved. At the governance level, the study underscores that complaint platforms are more than administrative tools; they are mechanisms for building trust between citizens and institutions. When properly managed, these platforms demonstrate that government is attentive to the voices of its people, which strengthens legitimacy and public confidence. Conversely, when complaints are ignored or responses are delayed, the system reinforces cynicism and deters participation. This dual potential highlight the necessity of evidence-based strategies guided by analytical methods such as clustering (Marzuki *et al*., 2023).

One of the strongest lessons from the findings is that participation is uneven across different regions and categories, which means that a one-size-fits-all approach is ineffective. High-reporting regions require strategies that focus on response speed and quality, while low-reporting regions demand interventions that prioritize digital literacy and accessibility. Medium-engagement regions should not be neglected; rather, they present opportunities to

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transform moderate participation into sustained involvement. By tailoring strategies to each type of community, governments can achieve more balanced outcomes and ensure that the benefits of digital governance are distributed equitably. This principle mirrors the philosophy of differentiated instruction in education, where teaching strategies are adapted to the diverse needs of learners to maximize engagement and outcomes (Gupitasari & Anwar, 2022).

Temporal variations also reveal critical points for intervention. The end-of-year concentration of complaints in Cluster 0 suggests that institutions must prepare for seasonal surges. This preparation might include increasing staff capacity, strengthening inter-agency coordination, and preemptively addressing known issues such as drainage before the rainy season. Similarly, the mid-year peaks in Cluster 2 emphasize the importance of monitoring during program implementation, when citizens are most attentive to service delivery. These findings advocate for cyclical planning in governance, where resources are allocated not uniformly but strategically in line with predicted demand patterns. In education, such cyclical planning can be applied by anticipating peak periods of student stress or administrative workload, such as during examinations or enrollment phases, and providing targeted support during those times (Hendrastuty, 2024).

The study also highlights the importance of transparency in complaint handling. Transparency is essential for sustaining trust because it assures citizens that their concerns are not only received but also acted upon. The use of dashboards and other visualization tools makes the process visible, reducing the perception of opacity and bureaucracy. By seeing the progress of their complaints, citizens are more likely to feel valued and remain engaged in the system. The same principle applies in education, where transparent communication about how feedback leads to changes can strengthen students' sense of belonging and responsibility within their institutions (Wulandari, 2023).

Another significant implication of the findings is the interplay between technology and digital literacy. Digital complaint platforms are only as effective as the citizens' ability to use them. Low participation in certain districts indicates that technological infrastructure and literacy remain barriers. Overcoming these requires not only technical investments, such as improving internet access, but also educational initiatives that promote digital competencies. Schools and universities can become strategic partners in this process by embedding digital governance awareness into curricula. For instance, students can be introduced to the concept of e-government and trained to use complaint platforms as part of civic education. This approach both empowers young people as digital citizens and extends the reach of governance systems to broader communities through peer and family networks (Larasati & Citrawan, 2024).

The clustering analysis also contributes to discussions on inclusivity. Data-driven systems must be designed with an equity lens to ensure that underrepresented voices are not excluded. By identifying low-reporting regions, clustering reveals where interventions are most needed to prevent marginalization. In public governance, inclusivity means ensuring that all citizens, regardless of geography or socio-economic status, have equal opportunities to participate. In education, inclusivity extends to ensuring that feedback mechanisms are accessible to all students, including those with disabilities or limited access to technology. Just as governments must address the digital divide, educational institutions must also ensure equity in how they gather and respond to student input (Anshori & Nuraini, 2020).

The findings also open opportunities for cross-sector collaboration. For example, local governments could work with educational institutions to integrate public complaint systems into student projects or research activities. Such collaboration would not only provide governments with valuable insights but also give students practical exposure to digital

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governance. This aligns with the concept of experiential learning, where education is enhanced through real-world engagement. By analyzing complaint data, students can develop analytical skills while also contributing to community development. This synergy between governance and education represents a novel way of linking academic objectives with societal needs (Sabani *et al*., 2023).

From a methodological perspective, the study demonstrates the utility of K-Means clustering as a tool for social research. While clustering is commonly used in technical domains such as marketing or traffic analysis, its application in governance highlights its versatility. By uncovering patterns that are not immediately visible, clustering provides deeper insights into complex datasets. This methodological contribution is valuable for future studies, which can adopt similar techniques to explore issues such as health service complaints, environmental monitoring, or student evaluations in higher education. The adaptability of clustering underscores its potential as a cross-disciplinary tool that bridges technical and social research (Utama, 2020).

Furthermore, the discussion affirms the importance of aligning governance initiatives with the Sustainable Development Goals (SDGs). Enhancing digital complaint systems directly supports SDG 16, which emphasizes peace, justice, and strong institutions. By promoting accountability and responsiveness, these systems contribute to building inclusive and transparent governance. In the context of education, the findings align with SDG 4, which advocates for quality education that is inclusive and equitable. By integrating digital literacy and participatory governance into educational processes, schools and universities can contribute to producing citizens who are not only skilled but also civically engaged (Marzuki *et al*., 2023).

In conclusion, the clustering results provide a multidimensional view of citizen engagement, highlighting variations across categories, regions, and time. These insights offer practical strategies for improving public service delivery and educational governance. They emphasize the importance of tailored interventions, cyclical planning, transparency, digital literacy, inclusivity, collaboration, methodological innovation, and alignment with global development goals. Together, these implications demonstrate that the use of data mining techniques in governance is not limited to technical optimization but extends to promoting broader social, educational, and developmental outcomes. By bridging governance and education, this study illustrates how digital tools can foster a culture of participation, trust, and accountability that benefits both institutions and communities.

4. CONCLUSION

The study demonstrated that K-Means clustering effectively uncovered complaint patterns across categories, regions, and time. The findings show that high-reporting areas require faster and higher-quality responses, while low-participation districts need targeted digital literacy and accessibility programs. Medium-level engagement suggests opportunities for strengthening participation through transparent feedback loops. These results are important because they emphasize that data-driven analysis can guide equitable and responsive policies. The study's novelty lies in linking digital governance with educational contexts, highlighting that clustering methods can enhance inclusivity, transparency, and accountability in both public services and education.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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