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Geographic Information System Impact on Urban Areas Management. A Case Study of Bandung, West Java, Indonesia

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ABSTRACT
Notwithstanding the increasing adoption of Geographic Information System (GIS) technologies in urban area management, there is a gap in understanding the comprehensive impact of GIS on decision-making, planning, and sustainable development. The existing literature provides insights into the evolutionary and technical aspects of GIS implementation, however, there is a need for empirical research to assess the broader implications, challenges, and opportunities that GIS presents for enhancing the efficiency, resilience, and inclusivity of urban areas management processes. The overarching research objective formulated out of this problem is to investigate the multidimensional impact of GIS on urban area management, addressing issues and variables such as data quality, accessibility, integration, and the socio-economic outcomes of GIS-based decision-making within urban contexts. Through exploring these scopes, the study seeks to contribute valuable insights to inform policymakers, urban planners, and practitioners about maximizing the benefits of GIS in the pursuit of more effective and sustainable urban governance. The gap in existing literature on the impact of GIS in managing urban areas is a research problem that sets the stage for a comprehensive exploration of the impact of GIS on urban area management, highlighting both technical and socio-economic dimensions. The research discovers specific aspects such as social and economic benefits, accessibility challenges, integration issues, and the broader implications for sustainable urban development. Institutional and household questionnaires were administered to solicit views for analysis to inform policy direction.to improve the adoption, integration, and implementation of GIS in managing urban areas of Bandung.

Keywords: Geographic Information System; Urban Areas Management; Sustainable Urban Governance; Socio-economic Outcomes; Urban Sprawl.

INTRODUCTION

Urban areas are complex environments characterized by diverse land uses, population concentrations, infrastructure networks, and socio-economic activities. Managing these dynamic urban sceneries requires effective planning, decision-making, and prudent resource allocation to address various challenges including urban sprawl, environmental degradation, and socio-economic inequalities. GIS technology has been developed as an innovative mechanism for urban area management, offering spatial analysis, visualization, and decision support abilities that enable stakeholders to better appreciate, plan, and manage urban environments.

GIS technology incorporates geographic data with analytical tools and visualization techniques to provide insights into the spatial patterns, relationships, and dynamics of urban areas. By leveraging spatial data on land use, demographics, transportation, utilities, and environmental conditions, GIS enables urban planners, policymakers, and practitioners to make decisions with a high level of precision and accuracy. In recent decades, urbanization has been a defining global trend, with more than half of the world's population now residing in urban areas [1]. This rapid urban growth presents unique challenges for urban planners, policymakers, and managers tasked with effectively managing and governing cities to ensure sustainable development, liveability, and resilience. GIS technology has emerged as an antidote to addressing these challenges by providing spatial data, analysis, and visualization capabilities for informed decision-making in managing urban areas.

GIS is a computer-based system designed to capture, store, analyze, and present geographical data, enabling users to understand spatial relationships, patterns, and trends within urban environments [2]. By integrating geographic information with various datasets, including demographic, environmental, infrastructural, and socio-economic data, GIS enables urban managers to gain valuable insights into the complex dynamics in shaping cities and devise effective strategies for urban planning, development, and management.

The impact of GIS on urban area management is complicated and encompasses several key dimensions: GIS enables urban planners to assess land suitability, identify development opportunities, and allocate land use efficiently. It facilitates the visualization of spatial patterns and trends, helping planners to optimize urban land use, reduce sprawl, and promote compact, sustainable development patterns, and GIS-based spatial planning tools support the integration of environmental conservation, infrastructure development, and socio-economic considerations into land use decisions, fostering more resilient and liveable urban environments. GIS provides valuable support for managing urban infrastructure, including transportation networks, water supply systems, energy grids, and public facilities. It allows for the mapping and analysis of infrastructure assets, maintenance needs, and service provision gaps, enabling efficient resource allocation and infrastructure planning. GIS helps cities optimize infrastructure investments, prioritize maintenance activities, and improve service delivery to residents. GIS facilitates environmental monitoring and assessment by integrating spatial data on air quality, water resources, green spaces, and biodiversity.

It enables urban managers to identify environmental hotspots, assess environmental risks, and implement measures for environmental protection and conservation [3]. GIS-based decision support tools support sustainable natural resource management practices, such as watershed management, urban forestry, and climate change adaptation. GIS plays a critical role in emergency response and disaster management by providing real-time spatial information for hazard mapping, risk assessment, and evacuation planning. It supports coordination among emergency responders, government agencies, and community organizations during crises, facilitating effective response and recovery efforts. GIS-based predictive modelling and scenario analysis help cities anticipate and mitigate the impacts of natural disasters, such as floods, earthquakes, and wildfires, enhancing urban resilience and disaster preparedness [4].

To summarize, GIS technology has become an essential device for urban area management, offering capabilities for spatial analysis, decision support, and visualization. Through harnessing the power of GIS, city managers can address the emerging complex challenges of urbanization more effectively, promote sustainable city development, and improve the quality of life for urban dwellers.

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1. LITERATURE REVIEW

Determining the most relevant authors in the field of GIS involves considering those who have made significant and impactful contributions through research, publications, and innovations. Here are several influential authors known for their contributions to GIS and related fields:

[5]. Roger Tomlinson, is often referred to as the "Father of GIS" for his pioneering work in developing the first GIS in the 1960s. Instrumental in the creation and application of GIS technology for land-use planning and resource management [6]. Helen and impactful contributions through research, publications, and innovations. Here are several influential authors known for their contributions to GIS and related fields:

Michael F. Goodchild: Known for Pioneering work in Geographic Information Science (GIScience) and spatial analysis [7]. Contributions: Research on spatial data modelling, uncertainty in GIS, and spatial statistics Couclelis: Known for: Research on geographic information systems, spatial analysis, and the social implications of GIS. Work focusing on human interactions with GIS, urban planning, and behavioral geography [8].

Karen Kemp is known for Extensive work in GIS education, remote sensing, and environmental monitoring [9]. Author of numerous GIS textbooks and publications, particularly in spatial analysis and environmental applications. Mark Monmonier: Known for: Contributions to cartography, geospatial intelligence, and critical analysis of GIS. Monmonier, Collier [10] Author of influential books on cartographic ethics, GIS-based surveillance, and map design.

David M. Mark: Known for: Work in GIScience, spatial cognition, and geographic ontology. Contributions [11]: Research on conceptual modelling, semantics in GIS, and geographic information modelling. Waldo Tobler: Known for: Tobler's First Law of Geography ("Everything is related to everything else, but near things are more related than distant things") [12]. Pioneering work in spatial analysis, cartography, and geographic information science. Sarah Williams: Known for: Research on spatial analysis, urban informatics, and the intersection of technology and urban planning [13]. Work on urban data analytics, geospatial technologies for urban planning, and civic technology.

NO.	Author	Title	Abstract	Research Focus	Relation to Topic
1	[14]	USGS compilation of Geographic Information System (GIS) Data of Coal Mines And Coal-Bearing Areas In Mongolia	A brief report summarizes the methodology used for the creation of the shapefiles and the chemical analyses run on the samples.	Coal Mines and Coal-Bearing Areas	Moderately related.
2	[14]	COMPS. 2015. USGS compilation of Geographic Information System (GIS) data representing Coal Mines and Coal-Bearing Areas of Mongolia	A brief report summarizes the methodology used for the creation of the shapefiles and the chemical analyses run on the samples.	Coal Mines and Coal-Bearing Areas	Moderately related.
3	[15]	Modeling land use changes at the peri-urban areas using geographic information systems and cellular automata model	The findings provide invaluable information for planners and decision-makers in managing and planning urban growth.	Urban planning.	Highly related.
4	[16]	Application of remote sensing data and geographic information system for identifying potential areas of groundwater storage in the middle Moulouya basin of Morocco	Five thematic maps of lithology, rainfall, drainage, lineaments, and slope; were respectively categorized as they were weighed. Capaciously, they have been used to generate the map of potential groundwater storage zones.	Potential groundwater zones.	Highly related.
5	[16]	Application of remote sensing data and geographic information system for identifying potential areas of groundwater storage in the middle Moulouya basin of Morocco	Five thematic maps of lithology, rainfall, drainage, lineaments, and slope; were respectively categorized as they were weighed. Capaciously, they have been used to generate the map of potential groundwater storage zones.	Potential groundwater zones.	Highly related.

The relevant Authors' articles' titles, abstracts, research focus, and how they relate to the chosen topic under review are indicated in Table 1. This clearly shows their research thematic clusters and focus. Out of the 9 most relevant Authors, two of them focused on developing the identification of groundwater using GIS. The other two also focused on the application of GIS in managing coal mining areas. One of them also focused on the application of GIS in the identification of medicinal species. The rest constituting the other four, focused on urban planning or settlement planning-related issues such as urban planning and urban development. None of these 9 Authors wrote directly on the

research topic and other searches conducted outside the Publish or Perish platform, such as Google Scholar have proven that the research topic for conducting this study does not exist in the available literature.

Considering the relationship of the research topic with the focus of the 9 relevant Authors, it indicates that, 6 of their research focuses were highly related to the chosen research topic except the other three that were moderately related. The implications are that: there was limited bias in the search for literature on the research topic. Also, the reliability of the outcome of the 350 selected literature is very high for triangulation that, the research topic is non-existent in the available literature. Conclusively, the Geographic Information System impact on urban area management is confirmed as a research gap for researchers to explore for further research in the quest to enhance sustainable cities.

Existing literature indicates that GIS impact on urban areas management research is still evolving and future research needs to be further expanded in the following aspects: Research on the application of GIS tools for managing urban areas is limited. Urban areas are growing rapidly which requires the application of GIS processes and mechanisms in dealing with this emerging challenge. One of the features of smart cities is the rigorous application of GIS in all spheres of the urban environment. Research on the evaluation of GIS impact on urban areas is paramount in the 21st century to inform future interventions to promote patronage in GIS applications in managing human settlements to enhance navigation, tracking, and monitoring of diverse human activities.

1. METHODOLOGY

Human ecology is concerned with the interrelationships among people in their spatial setting and physical environment [20]. A case study research method is an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not evident; and in which multiple sources of evidence are used [21].

The case study allows one to investigate and understand the dynamics of a particular system with the attributes of investigating a contemporary phenomenon within its real-life context [22]. It is an ideal approach for a phenomenon that is ongoing, and when boundaries between the phenomenon and the context are not clearly defined. It is considering this as well as the availability of multiple sources of evidence that makes the adoption of this approach imperative in this instance.

The objectives of the study are: to evaluate how GIS tools and spatial analysis techniques improve the efficiency and effectiveness of urban planning activities, such as land use zoning, transportation planning, and infrastructure development. This goal entails assessing how GIS technology improves urban planning processes, to investigating how GIS-based platforms and tools support community involvement in urban planning processes by allowing stakeholders to offer feedback, visualize scenarios, and work together on decision-making. This objective entails exploring the use of GIS for community engagement and participatory decision-making, to look at the socio-economic effects of GIS adoption in urban areas: This aims to comprehend the wider socio-economic effects of GIS technology on urban development, including how it affects social equity, property values, economic growth, and quality of life. The objective of this study is to identify and analyze the obstacles and constraints that may impede the successful adoption and utilization of GIS technology in urban areas.

These may include technical limitations, institutional barriers, and data accessibility issues. The goal is to identify challenges and barriers to the effective implementation of GIS in urban areas. Finally, to make recommendations for improving the integration of GIS into management techniques for urban areas: This goal is to create workable plans, standards, and best practices for utilizing the advantages of GIS technology in infrastructure and urban planning.

Instruments were prepared to identify and gather relevant spatial datasets for the study area, including geographic data layers such as study area boundary map, land use/land cover, transportation networks, infrastructure assets, environmental features, and socio-economic indicators. This questionnaire was administered at the Physical Planning Office at Bandung Municipal Office. However, 30 household or citizen questionnaires were administered to gather primary information for analysis of the impact of GIS on managing urban areas.

Conduct case studies of cities or urban regions that have successfully integrated GIS into their management practices. Bandung was purposely selected for this research to investigate the impact of GIS Technologies on socio-economic development. The rationale for selecting Bandung is to assist in analyzing the correlation between Geographic Information Systems and urban area management. Which qualifies this research as a descriptive one. Units of inquiry are the general public and the Municipal Planning Office for primary data. In determining the spatial extent and scale of the study area, the following maps are presented:

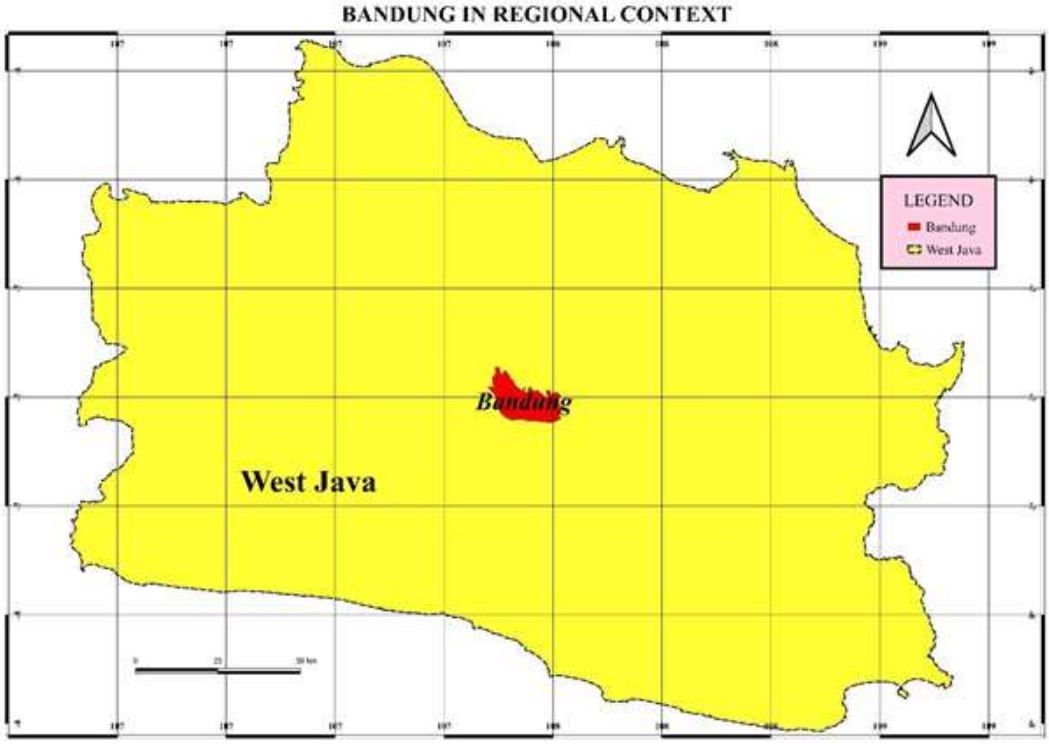

Figure 1: Map of Bandung in Regional Context

Source: Authors' Construct, 2024

Bandung is located in the Region of West Java of Indonesia in the Continent of Asia. Figure 1 depicts the geographical position of the study area in a Regional context. The legend on north eastern side of Figure 1 explains the location and limit of West Java and Bandung.

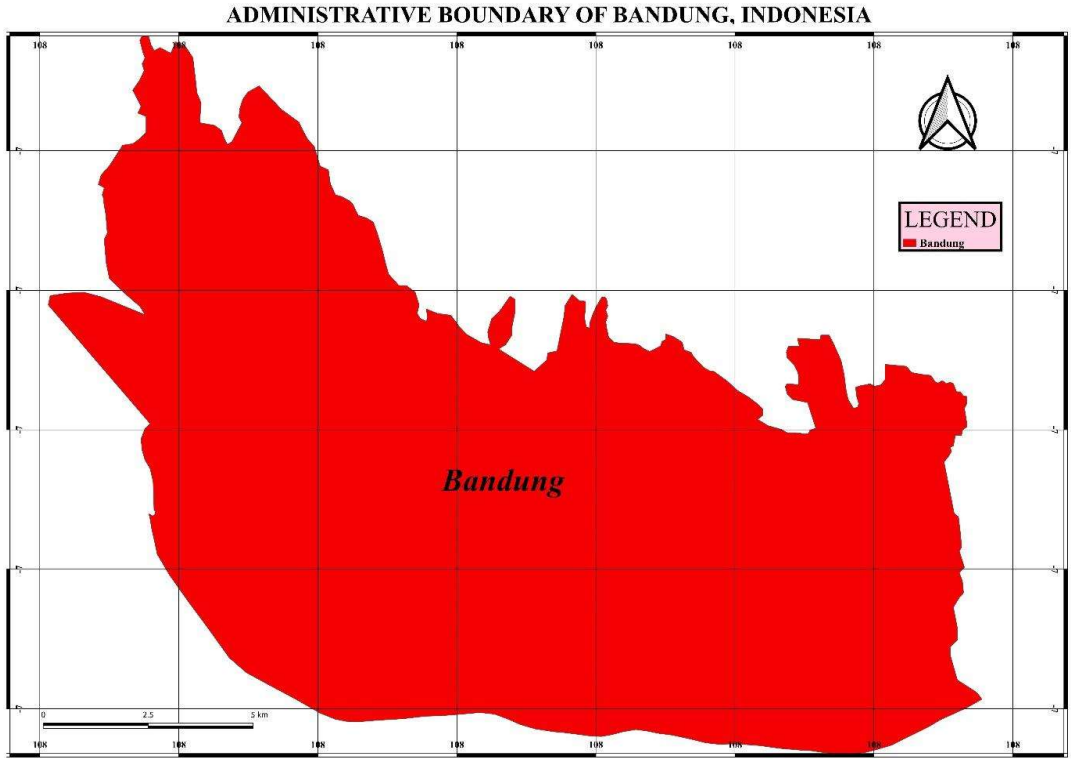

Figure 2: Map of Bandung

Source: Authors' Construct, 2024

The total land area of Bandung City is 167.31 km^2 and consists of 30 sub-districts (Kecamatan) which are further divided into 151 Urban Villages (Kelurahan). Bandung is located at Latitude 6.9175^0 S and longitude 107.6191^0 E. In Figure 2, the legend on the northeastern side depicts the administrative boundary map of Bandung.

2. FINDINGS

Synthesizing the findings from the data collected from citizens in Bandung, tabulation was made from the responses captured from the administered questionnaire. The processing of tables was analyzed using an Excel sheet to produce pie charts and histograms to aid in evaluating the impact of GIS on urban area management by comparing outcomes, processes, and decision-making after the implementation of GIS technology. The outcomes of the primary data captured are demonstrated below:

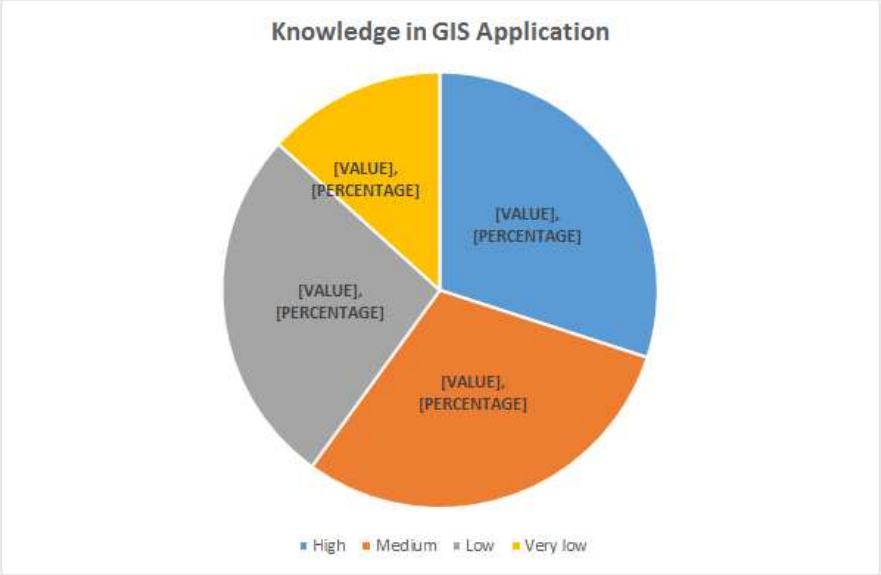

Figure 3: Major Roads Map

Source: Authors' Construct, 2024

It can be observed from Figure 3 that 30 percent of the citizens interviewed had both high and medium knowledge of GIS. However, 27 and 13 percent of those interviewed had low and very low knowledge of GIS respectively. Inferring from this outcome, it can be declared that, in Bandung, most of the population that is 60 percent are well abreast with the usage of GIS to be applied in areas required in their life.

Those who have little or very little knowledge of GIS constitute 40 percent which is a challenge to reckon with in promoting the GIS era in the 21st century.

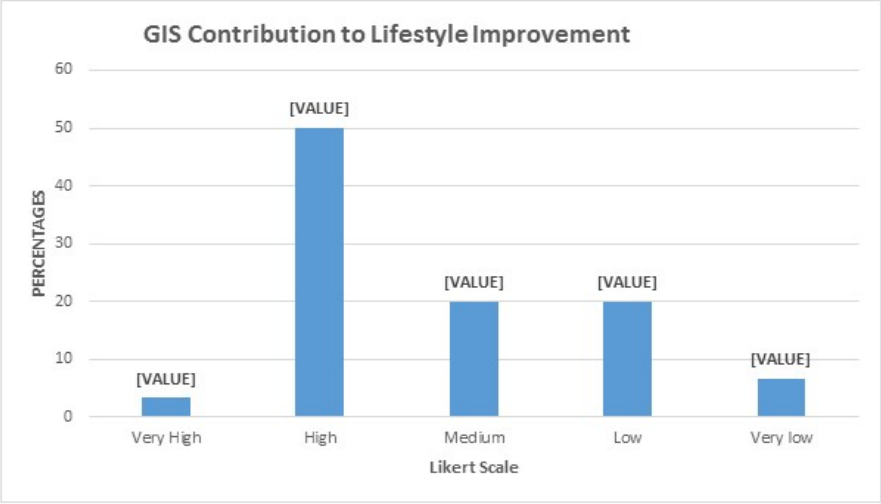

Figure 4: Major Roads Map

Source: Authors' Construct, 2024

Figure 4 shows GIS's contribution to lifestyle improvement. 20, 50, and 3.3 percent represent medium, high, and very high GIS contributions to lifestyle improvement respectively. Since ranging from medium to very high constitute 73.3 percent, the implication is that GIS has had a significant impact on improvement in the lifestyle of the people of Bandung. Notwithstanding these achievements, 26 percent of the populace has not benefitted from GIS interventions for lifestyle improvement remains limited. Attention needs to be paid to investigate why 26 percent of the population has not seen improvements in their lifestyle since the advent of GIS technologies.

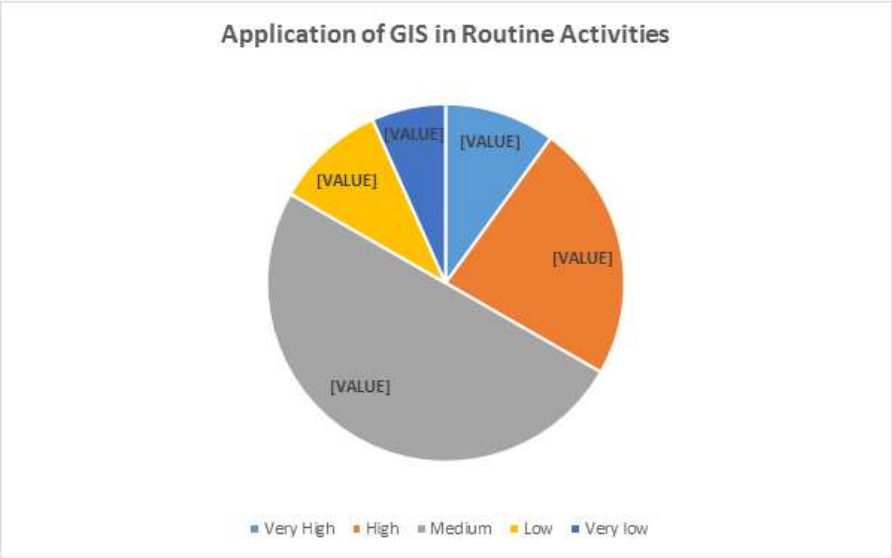

Figure 5 Major Roads Map

Source: Authors' Construct, 2024

Geographic information systems (GIS) and spatial analysis are used to model the relationship between the daily routine activities of youth and rates of violence and provide an example of how these techniques can be applied to analytical studies examining violence in places [23].

People's daily activities are influenced by GIS in terms of professional work environment and spatial dynamics. Remote sensing has embedded sensors to give early warnings and signals to pre-empt weather forecasts and provide sensitive land-sat information on earthquake-prone, flood, and general disaster maps to serve as a guide to people's activities.

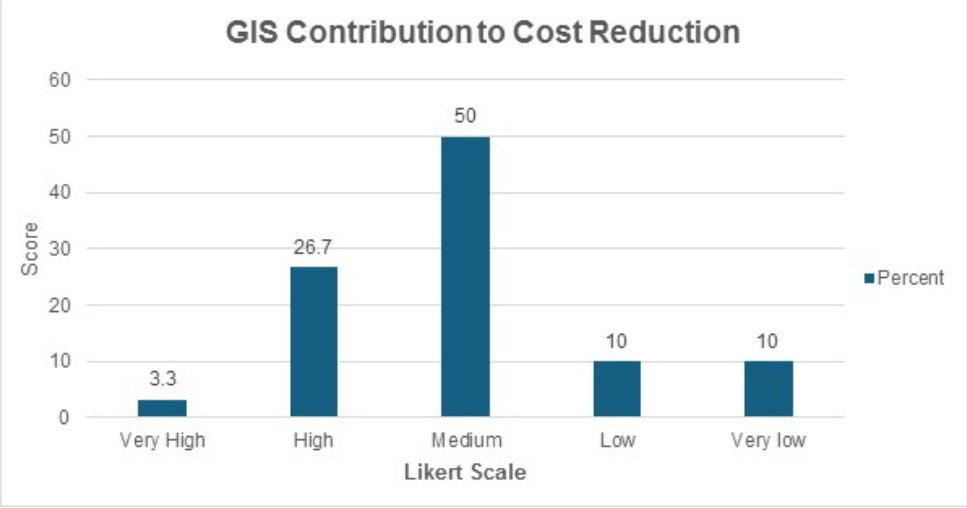

Figure 6 Major GIS Contribution to Cost Reduction

Source: Authors' Construct, 2024

Cost reduction in the use of GIS adds value to peoples' income through savings made in patronizing GIS technology applications. This is manifested in terms of Google applications such as Google Drive, Google Locational Maps, and GPS Waypoints. These GIS applications provide directions by coordinating directions that minimize losing directions to specific destinations which can cause time and financial losses.

From Figure 6, 50, 26.7, and 3.3 percent of the interviewed population had a medium, high, and very high reduction in cost as a result of utilizing GIS applications respectively. Medium, high, and very high are encouraging results therefore cumulatively 80 percent under these circumstances is a positive outcome. However, 10 and 10 percent in low and very low-cost reduction in utilizing GIS applications respectively by the interviewed population is marginal as compared to 80 percent for those who have medium, high, and very high-cost reduction in GIS applications. Despite this success, there is a need to research why 20 percent of the population has not significantly benefitted from cost reduction as a result of leveraging GIS applications.

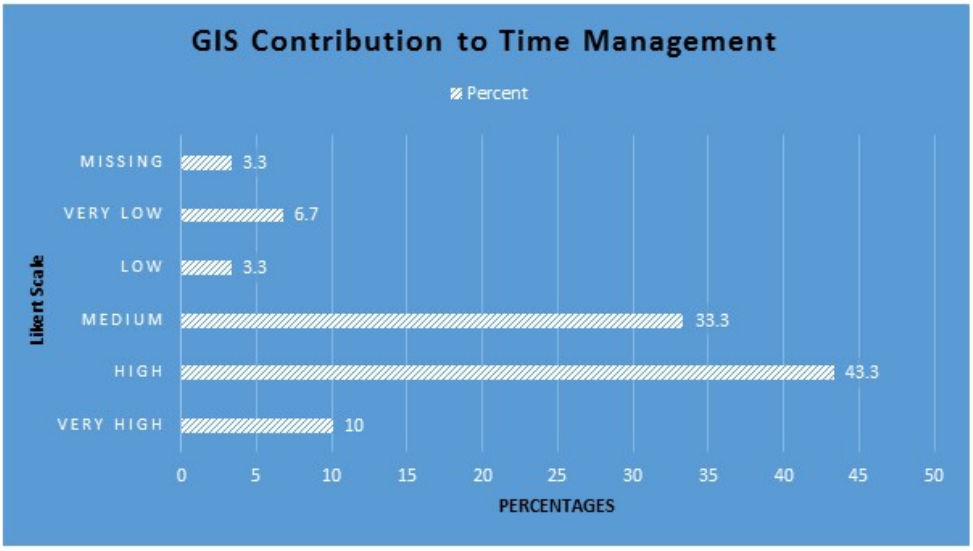

Figure 7: GIS Contribution to Time Management

Source: Authors' Construct, 2024

Time translates into monetary resources as it is used for the production of goods and delivery of services. Efficiency in the usage of GIS applications has the potential to reduce the waste of time in many hours that would have been used profitably.

Figure 7 indicates that 33.3, 43.3, and 10 percent represent medium, high, and very high GIS contributions to time management. The cumulative of medium, high, and very high is 87.6 percent. Conversely, 3.3 and 6.7 represent low and very low responses from the 30 respondents respectively. This means that a limited number of 10 percent of those interviewed have both low and very low benefits in terms of GIS contribution to time management. Comparing those in low and very low totalling 10 percent to those of medium, high, and very high totalling 87.6 percent, it can be concluded that GIS has impacted positively on time management of the people of Bandung.

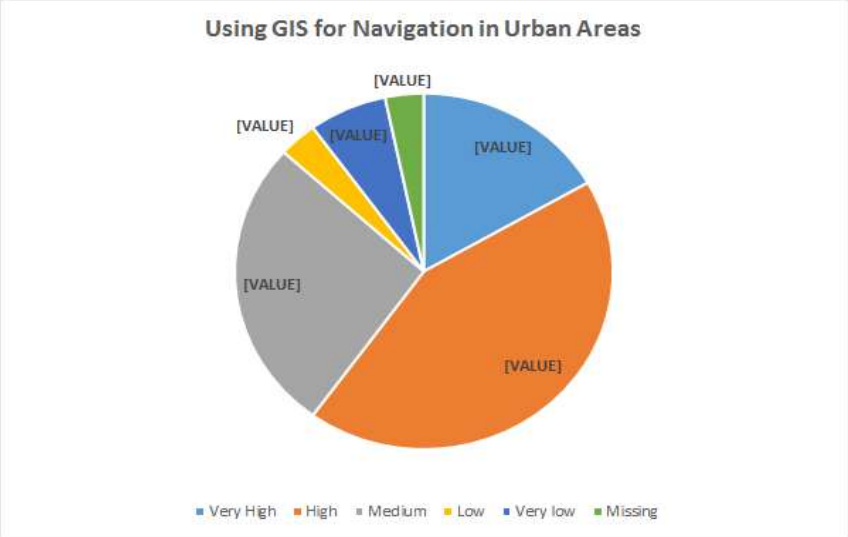

Figure 8: Using GIS for Navigation in Urban Areas

Source: Authors' Construct, 2024

Locating essential services is necessary for visitors, tourists, and indigents. Urbanization has become widespread and complicated. Google locational applications are nowadays available on Android phones to provide directional maps for easy navigation in megacities and megalopolises. Hitherto, several visitors lost direction to their destinations because these GIS technologies had not been introduced.

It can be inferred from Figure 8 that medium, high, and very high constitute 26.7, 43.3, and 16.7 percent respectively. The aggregate of medium, high, and very high is 86.7 percent. However, low and very low constitute 3.3 and 6.7 respectively which gives a sum of 10 percent. Comparing the two results implies that, the majority of those interviewed leverage GIS for navigation in town which is a very impressive performance for an emerging economy like Indonesia. The 10 percent for low and very low although very low need to be reckoned with to further reduce the percentage in the low range patronage in using GIS for navigation in urban areas

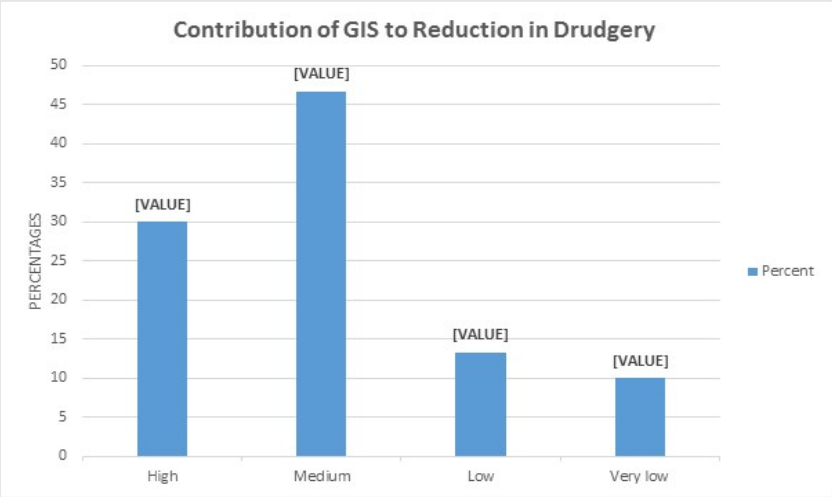

Figure 9: Contribution of GIS to Reduction in Drudgery

Source: Authors' Construct, 2024

Applying GIS in the dispensation of related activities reduces stress and exerts more energy before getting results. Since GIS has automation embedded in it, its operations are powered by sensors and generate results without applying physical force. This hallmark of GIS makes it drudgery-free.

It can be deduced from Figure 9 that medium and high constitute 46.7 and 30 percent respectively. The aggregate of medium and high is 76.7 percent. However, low and very low constitute 13.3 and 10 percent respectively which gives a sum of 23 percent. Comparing the two results implies that, the majority of those interviewed appreciate GIS's contribution to the reduction in drudgery. The 23.3 percent for low and very low constitute a research problem that needs to be investigated to address the causes and recommend solutions for adoption to encourage others to appreciate the intrinsic value of GIS in reducing drudgery.

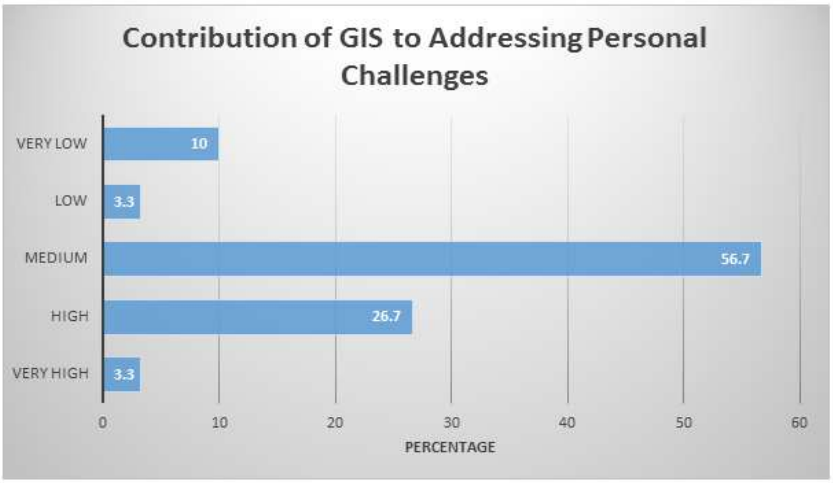

Figure 10: Contribution of GIS in Addressing Personal Challenges

Source: Authors' Construct, 2024

Personal challenges defer from one person to another because of individual differences, GIS is common to all for assessment depending on the level of knowledge in that discipline. Some people have developed specialized skills in GIS such as consultants, Lecturers, and Engineers among other disciplines. Leveraging GIS has sustained people's livelihoods in diverse ways. Challenging situations such as finding the location of a facility or unknown locations can be solved through the use of GIS Technologies.

It can be deduced from Figure 10 that medium, high, and very high constitute 56.7, 3.3, and 10 percent respectively. The aggregate of medium, high, and very high is 7o percent. However, low and very low constitute 26.7 and 3.3 respectively which gives a sum of 30 percent. Comparing the two results implies that, the majority of those interviewed depend on GIS for solving for solving personal challenges which is a very impressive performance for the people of Bandung. The 30 percent for low and very low although is low need to be considered to further reduce the percentage in the low range in using GIS for solving personal challenges.

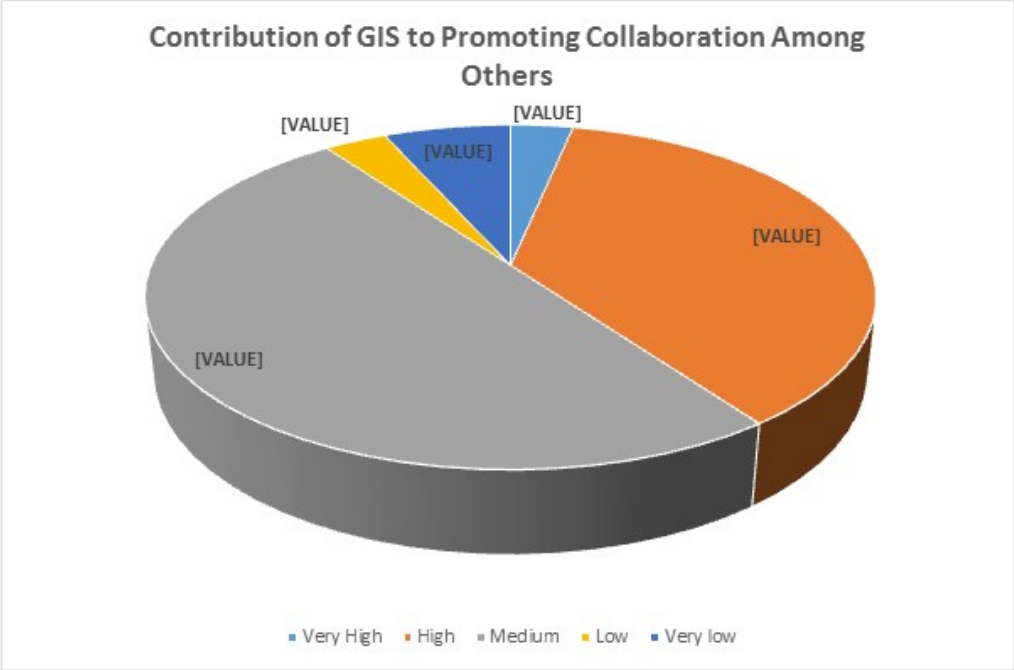

Figure 11: Contribution of GIS to Promoting Collaboration among Others

Source: Authors' Construct, 2024

GIS has the potential to bring stakeholders together on a common platform to share ideas and knowledge through the sharing of GPS coordinates about the venue of a meeting or a gathering. This innovation has brought together strangers and visitors to convergent points without missing the venue.

In Figure 11, 50, 36.7, and 3.3 percent represent medium. The high and very high contribution of GIS to promoting collaboration among others respectively. The aggregate of the medium, high, and very high is 90 percent. This implies that 90 percent of those interviewed appreciate the fact that GIS has contributed to promoting collaboration among others. Notwithstanding, this significant achievement, 3.3 and 6.7 percent represent low and very low contributions of GIS to promoting collaboration among others respectively. Out of the 30 people interviewed, those in the low range sum up to 10 percent. Although the 10 percent seems insignificant, there is a need to research why GIS has not contributed immensely to promoting collaboration among others.

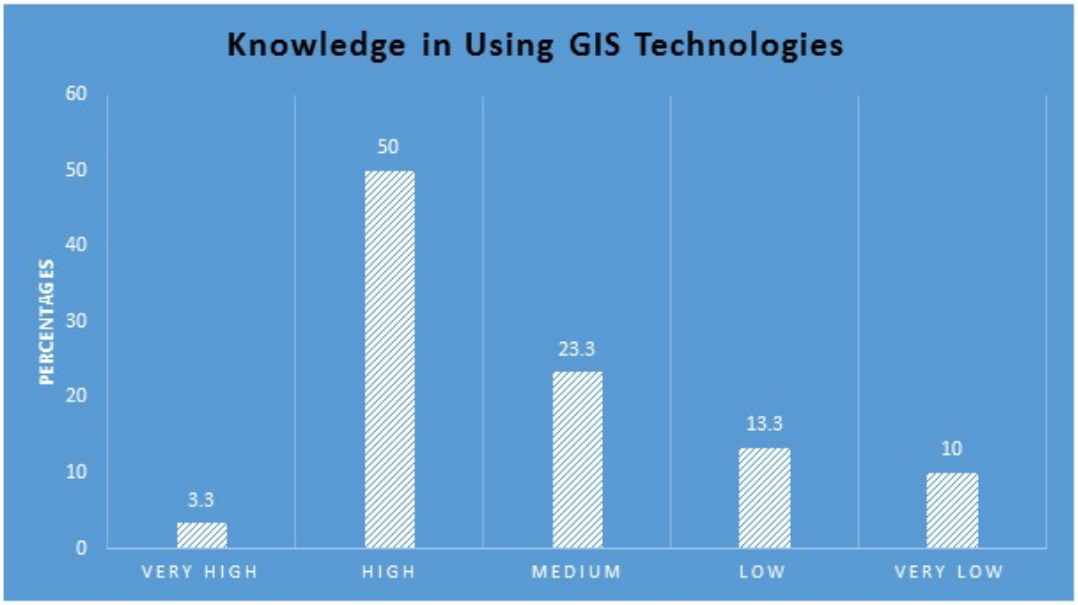

Figure 12: Knowledge in Using GIS Technologies

Source: Authors' Construct, 2024

The citizens require minimum or basic knowledge of GIS to apply it effectively in every endeavor. People's ability to apply GIS technologies depends to a large extent on their knowledge and ability to use it. It can be observed in Figure 12 that, 23.3, 50, and 3.3 represent medium-high and very-high knowledge in GIS Technologies respectively. The sum of 76.6 percent of those interviewed have medium, high, and very high knowledge of GIS Technologies which is very impressive for its adoption in Bandung. However, 13.3 and 10 percent represent low and very low knowledge of GIS Technologies. The sum of these is 23.3 percent.

The 23.3 percent who have low and very low knowledge of GIS need to be addressed by embarking on an education and sensitization drive to ensure that people are informed about the advent of GIS Technologies to increase their knowledge of it.

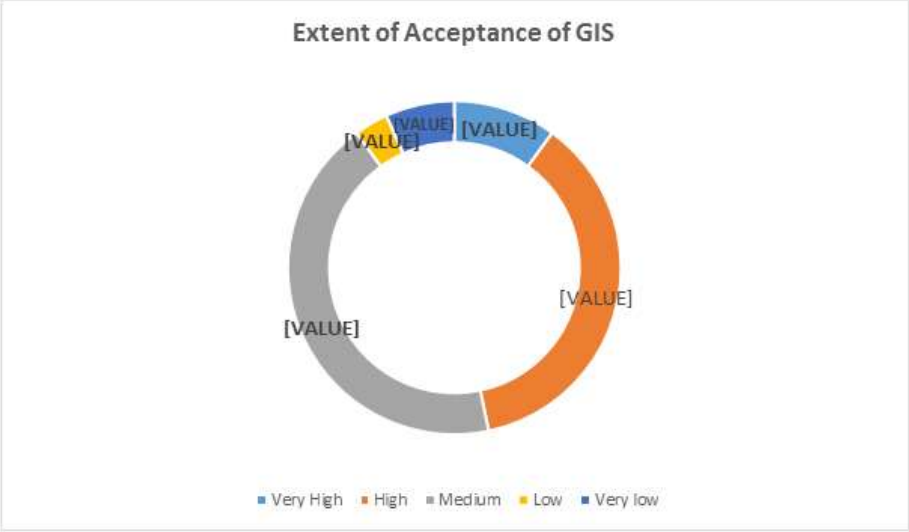

Figure 13: Extent of GIS Acceptance

Source: Authors' Construct, 2024

GIS adoption needs to be accepted by the general public for implementation before its benefits can be out scaled. Figure 13 indicates that 43.3, 36.7, and 10 percent as medium, high, and very high acceptance of the GIS respectively. The aggregate of these is 80 percent which can be generalized that the people of Bandung have welcomed and accepted GIS as a means for all the variables enumerated above as innovation in the 21st century as a paradigm shift from a manual era to a digitized and modernized era.

It can also be generalized that digitized transformation has taken place in Bandung as a chunk of the population has expressed interest in accepting GIS innovation as a means of life improvement intervention which conforms to the changing generation and the post-modernism epoch.

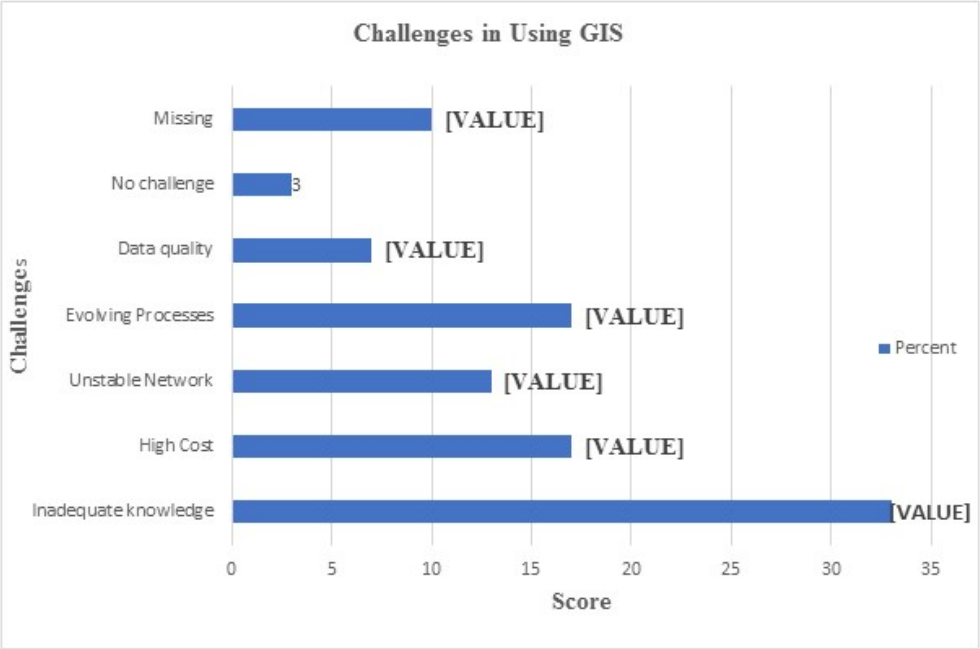

Figure 14: Challenges in Using GIS

Source: Authors' Construct, 2024

Most of the teaming youth have accepted the advent of GIS in the dispensations within the modern era, however, there are challenges in applying the GIS concept. Among these challenges are: inadequate knowledge, high cost, unstable network, evolving processes, and data quality according to the section of the population of Bandung interviewed.

It can be inferred from Figure 14 that inadequate knowledge, high cost, unstable network, evolving processes, and data quality constitute a percentage of 33, 17, 13, 17, and 7 respectively. Among these challenges, inadequate knowledge constitutes the highest which is 33 percent, followed by high cost and evolving processes both constituting 17 percent each. The third challenge is evolving processes also constituting 13 percent and finally data quality constituting 7 percent.

From the foregoing analysis, it can be observed that inadequate knowledge of GIS constitutes the biggest challenge. Impliedly, most of those interviewed, 33 percent complained of not having sufficient knowledge to leverage GIS applications. High cost and evolving processes rank second among the challenges constituting 17 percent. The monetary value placed on GIS coupled with its changing nature in terms of processes needs attention in the quest to promote its patronage.

Network instability is another challenge that takes 13 percent, with serious attention as the fuel for using most GIS applications is mobile networks. The last but not the least challenge is GIS data quality which is 8 percent. GIS data is in two forms, raster and vector layers. The quality of these data sets determines the outcome of the data processed. 3 percent of the participants indicated that they do not have any challenge in using GIS, however, 10 percent of them did not indicate any challenge on the questionnaire declaring it as missing.

3. RECOMMENDATIONS

The highest challenge is inadequate knowledge in GIS which constitutes 39 percent of the respondents. It is, therefore, necessary for Technical Personnel, Government Representatives, Urban Planners, and Community People who are involved in the implementation of GIS training and capacity-building initiatives to provide online courses, television tutorials, workshops, and seminars to improve knowledge of GIS applications, tools, and concepts related to urban area management. Also, it is important to encourage cooperation to share best practices, expertise, and implementation lessons learned from GIS projects with academic institutions, research groups, and business specialists.

High cost constitutes 17 percent of the challenges in using GIS. To reduce the costs of GIS infrastructure through the following: software licensing, and training, target cost-sharing plans, and collaborations with governmental bodies, businesses in the private sector, and charitable groups. Give preference to cloud-based and open-source GIS applications since they frequently have more affordable upfront charges and flexible payment options than proprietary

software. Perform cost-benefit assessments to illustrate the return on investment (ROI) and long-term economic benefits of using GIS in terms of enhanced service delivery, resource optimization, and socioeconomic development.

To reduce downtime and provide ongoing access to GIS data and applications, even in the case of network outages, implement redundancy measures, backup systems, and failover procedures. To offer dependable access in places with inadequate network coverage, investigate alternate network options such as mesh networks, satellite internet, and mobile data networks. Network instability is another challenge that takes 13 percent. By deploying wireless technologies, expanding service areas, and upgrading broadband networks, invest in enhancing network infrastructure and connectivity.

To promote cooperation, communication, and flexibility in response to changing needs and procedures, form interdisciplinary working groups and cross-functional teams.

To integrate suggestions, lessons discovered, and industry best practices into urban management procedures, routinely review and update GIS workflows, standards, and protocols. Network instability is another challenge that takes 13 percent. When implementing GIS, use agile project management techniques and iterative development methods to adapt to changing stakeholder needs, evolving requirements, and emerging technology.

To get high-quality spatial data for managing metropolitan regions, invest in data-collecting technologies like crowdsourcing, satellite photography, and remote sensing. Data quality challenge constitutes 7 percent of the challenges in using GIS. Establish and implement data quality standards, procedures, and guidelines to guarantee the dependability, completeness, and accuracy of GIS data utilized in analysis, urban planning, and decision-making.

Use processes for data validation, verification, and cleansing to find and fix mistakes, inconsistencies, and discrepancies in GIS datasets.

4. CONCLUSIONS

This research was initiated based on a bibliometric literature review conducted and published on “Bibliometric analysis of Geographic Information System Impact on Urban Areas Management” which identified an empirical research gap that needs to be investigated to fill the knowledge gap in the literature to promote the application of GIS in the 21st century as an era digitization revolution in dealing with complex societal challenges. The 30 participants interviewed represent the sample taken from Bandung for this empirical research. The institutional questionnaire was also administered for the Bandung Municipal Spatial Planner to collate views on spatial data management through GIS and other related issues on GIS applications in support of decision-making.

The research study has discovered the sophisticated ways that Geographic GIS technology influences the management of metropolitan areas, emphasizing the important ways in which it improves community involvement, planning, infrastructure management, and environmental sustainability. A thorough examination of the literature, case studies, and empirical analysis leads to the following important conclusions: Urban planning procedures can be made more effective and efficient with the use of GIS technology.

The institutional data collected from the Bandung Municipal Assembly indicated that GIS is an antidote in dealing with spatial planning dynamics. Strategic land use management, efficient resource allocation, and informed analysis are made easier by GIS's capacity for spatial analysis, modeling, and visualization. Using GIS tools to optimize the management of urban infrastructure assets, such as public buildings, utilities, and transportation networks, is essential. GIS-based asset management platforms provide improved asset monitoring and maintenance planning.

By offering instruments for tracking, evaluating, and reducing environmental issues, GIS technology supports urban environmental management. GIS facilitates proactive environmental stewardship and resilience-building in urban contexts, ranging from monitoring air and water quality to developing green spaces and mapping natural hazards.

Through participatory mapping tools and GIS-based platforms, communities can express their concerns, take part in urban planning processes, and work together to make decisions. Through encouraging openness, diversity, and citizen empowerment through GIS-based technologies.

The recommendations proposed can be applied to improve GIS adoption and enforcement in Bandung and other jurisdictions to enhance its rippling benefits. Although the advent of GIS has brought enormous benefits to society, there are seeming challenges that need serious attention to promote its enforcement. In the revolutionizing digitization era in the 21st century as a paradigm shift from manual dispensation to a GIS approach, there is the need to embrace GIS as an antidote to societal challenges especially management of big data.

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