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STRATEGIC SPATIAL PLANNING FOR DISASTER RISK MANAGEMENT IN THE BONO REGION OF GHANA

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Abstract: The adverse impact of climate change has necessitated the global community to leverage spatial planning to curb the negative impacts of such incidents. Disasters continue to occur in human settlements, which makes it necessary to develop resilience through spatial planning strategies. The research question underpinning this study is, how can disaster resilience be improved through spatial planning strategies? Reducing the impact of natural and anthropogenic hazards on communities requires enhancing disaster resilience through spatial planning techniques. The main objective is to promote land use policies that seek to mitigate the impact of disasters on communities in the Bono Region. The questionnaires were administered using the Kobo Toolbox software. The total number of questionnaires administered was 667 which was analyzed using Excel and application of the Mann-Whitney U Test for the hypothesis testing. The major findings were: 35% indicated that there is low enforcement of spatial plans, 42.68% of the respondents indicated low and very low effectiveness of urban governance institutions and 40.47% indicated that there is low and very low access to information and community engagement. The poor degree of spatial planning strategies that was discovered is further supported by the 62.8% of respondents who indicated that there is inadequate ability for disaster resilience within the research region in the previous conversations. Hazard assessment, land use planning, infrastructure resilience, community involvement, and policy integration can all be combined to significantly improve an urban area's capacity to withstand and recover from disaster events.

Keywords: Disaster Resilience, Spatial Planning Strategies, Vulnerable Communities, Sustainable Future, Climate Change Adaptation

Introduction

Development in high-risk, to foster collaboration among community members, and governmental and non-

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Disaster occurrence continues or intermittently causes shocks to humanity through the destruction of property or lives. The psychological trauma caused by the incidence of disasters either artificial or natural should be anticipated through strategic spatial planning. This research aims to furnish scholars with an up-to-date assessment of citizens on disaster occurrence in the Bono Region as a result of ineffective spatial planning practices that do not integrate disaster resilience. Most suburbs in the study area are not properly planned and fall short of disaster resilience strategies to mitigate disaster in the event of its occurrence. The study's question is, how effective have spatial planning practices integrated disaster resilience measures in the study area? The study's objectives are: To promote land use policies that seek to mitigate the impact of risk, such as controlling governmental agencies to ensure a strategic approach to disaster resilience through information sharing and to establish mechanisms for monitoring and evaluation of disaster resilience measures based on lessons learned. These objectives entail identifying the enforcement of spatial planning strategies for disaster resilience through community engagement and participatory decision-making, to look at the socio-economic effects. This aims to comprehend the wider socio-economic effects of spatial planning approaches including participatory planning and enforcement of building regulations. These may include technical limitations, institutional barriers, and data accessibility issues. Also to identify challenges and barriers to the effective enforcement of spatial planning strategies. The sustained progression of a field of research largely depends on the continuity and growth of research knowledge and capabilities (Woolley et al., 2019). For a discipline to advance and gain insights into potential future developments and consequences that add to the body of knowledge, there must be awareness of its past patterns. In general, the main purpose of the literature review is to analyze what has already been done in the field. Empirical studies despite contributing significantly to the development of knowledge, require primary data to substantiate the research problem. The initiation of this empirical paper is based on gaps in the literature captured in a systematic literature review that sets an ambition to contribute to the body of knowledge hitherto conducted and open new windows for grey areas for researchers to explore in the quest to safeguard humanity against disaster occurrence through spatial planning strategies. Strategizing against disasters is the prior objective of most nations in an attempt to adopt a proactive approach to disasters instead of a reactive one. In 2017 alone, more than 200 papers were published on resilience in the field of risk and disaster management, a sevenfold increase from ten years earlier (Graveline and Germain, 2022). The presence of natural disasters looms large, often striking with devastating consequences, especially in vulnerable communities. With the increasing frequency and intensity of these events attributed to climate change, the imperative to fortify communities against their impact has reached critical importance. The EU has made a strong case for itself as the world's pioneer in advocating for and executing Nature-Based Solutions (NBS) (Davies et al., 2021). Although the majority of development initiatives are not labeled as climate change adaptation, they probably have an impact on communities' ability to adjust to shifting shocks and trends. The result of climate change or other pressures associated with development has necessitated spatial planning strategies. To start figuring out how adaptive ability may be fostered through broader development processes at the local and national levels, a framework for comprehending and evaluating it at the local level is required. With time, a framework like this may be used as a platform to track advancement, pinpoint requirements, and allot development funds to improve a system's capacity for change adaptation. The traditional planning approach, characterized by its rigid methods and tools, is inadequate for effecting comprehensive societal change. In contrast, strategic spatial planning is considered a more proactive approach that demands innovative

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practices. Spatial planning is an essential preventive approach in disaster risk reduction that helps to enhance resilience and mitigate vulnerabilities. However, conventional top-down methods often fail to address the complex needs and dynamics of marginalized communities. The purpose of this research is to determine how a glowing strategic approach can be integrated into spatial designs to build synergy for disaster resilience in areas that are susceptible to disasters. Strategic planning is crucial in these situations because they combine environmental risk, poor infrastructure, and social disparity.

Literature Review

Disaster resilience is building synergy against disaster occurrence to ensure a reduction in the impact of disaster to an appreciable level. Renschler et al. (2010) recently developed a draft framework for measuring disaster resilience. There are seven elements in the framework (Represented by the acronym 'PEOPLES') which represent both what we want to protect and resources that provide protection. The framework to some extent seems to confound the roles of 'protected' and 'protection' in the sense that each element in the framework fills both roles. The framework does not make the respective roles of 'protected' versus 'protection' clear. Here we are interested in the elements of the framework as things we want to protect. The elements in the framework are: Population and demographics, environmental/ecosystem, organized governmental services, physical infrastructure, lifestyle and community competence, economic development, and social-cultural capital. Chae (2018) postulates that the life cycle of a disaster most emergency management cycles include four phases of management: Preparedness, response, recovery, and mitigation. Prevention might be considered an additional phase. Prevention refers to the active implementation of the plans or preparations identified in the Preparedness phase. Preparedness: Generally, preparedness includes making plans or preparations to save lives, minimize disruption, and help with response and rescue operations. Activities related to preparation happen ahead of time. As an example: Make an escape strategy. Identify lines of succession. Prevention in this expanded model includes making the actual preparations to save lives, minimize, disruption, and help with response and rescue operations. Most prevention activities take place before an event, but some may take place during an event. Response: Response includes all the actions taken after an event to protect citizens and to prevent and minimize property damage after an event. Response activities take place during an event. Examples: Seek shelter during a weather event. Practice social distancing during a pandemic. Evacuate citizens. Position assets in safe locations (Chae, 2018) Recovery: Recovery activities are the actions taken to return to a normal (or even safer) situation following an emergency. Recovery takes place after an event. These activities begin as soon as the immediate danger is over. Examples: Remove debris. Repairing and replacing damaged structures. Provide temporary housing. Mitigation: Any actions taken to avert an emergency, lessen its likelihood, or lessen the negative consequences of an inevitable disaster are referred to as mitigation. These activities can take place before or after an emergency. Examples: Buying flood insurance before an event. Drying wet items to prevent mold. Follow established standards in construction. Promulgate drought contingency ordinance (Chae, 2018). Preparing for disaster is planning against the occurrence of eventualities or incidents. Spatial planning strategies are physical planning methods to mitigate disaster occurrence. Japan is known for its stringent building codes and extensive public education programs, Japan's spatial planning strategies include extensive use of hazard mapping and development restrictions in highrisk zones. A key objective outlined by the Sendai framework for disaster decrease 2015–2030 is understanding the location of risk to natural disasters, specifically the regions of high exposure and vulnerability, to achieve a

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significant decrease in disaster risk. Moreover, it is an essential tool for decision-making for those in charge of disaster mitigation in Japan and other countries (Raduszynski and Numada, 2023). In the Netherlands, the Room for the River project exemplifies how spatial planning can enhance resilience by creating floodplains and green spaces to manage flood risk. Planning practitioners can evaluate how networks of plans impact community vulnerability using the Plan Integration for Resilience Scorecard (PIRS). This analysis shows how much plans at various administrative scales target the most geographically vulnerable areas in terms of social, physical, and environmental factors. It can be used to support the ambitious goals of a program like Room for the River and align them with local development priorities (Yu et al., 2020). After Hurricane Sandy, New York City, USA, launched the Special Initiative for Rebuilding and Resiliency (SIRR), which aims to increase urban resilience through zoning modifications, infrastructure upgrades, and community involvement. Finn et al. (2023) assert that the New York City metropolitan area, including the suburban Long Island shoreline and the New Jersey coastline, was severely damaged by Superstore Sandy in 2012 (Kunz et al., 2013). With the region's breadth, congestion, complexity, and variety, several strategies have been employed to deal with post-storm recovery. Organizing has been essential to these initiatives. This examination of the planning responses to Sandy, which included in-depth interviews with recovery stakeholders, shows the kind of resources and procedures that support this approach and provides an emerging model of resilient recovery planning. We propose that resilience-focused Sandy recovery planning procedures rely heavily on pre-existing planning ability, strong political leadership, and non-profit financing assistance. Contextualizing literature in the study area, Awuni et al. (2023) review the impact of climate change and some interventions made toward its management. The study explored peer-reviewed journals, policy documents, and technical reports for relevant materials that chronicle programs and measures to address the challenges of climate change. The research revealed that Ghana had experienced about 1°C rise in temperature over the past four decades and sea level rise with socioeconomic consequences including decreased agricultural productivity and inundation of coastal communities. Policy interventions have resulted in the introduction of several mitigation and adaptation programs, such as building resilience in various economic sectors. Disaster occurrence in the study is caused by climate change, however, land use planning or spatial planning strategies are one of the mechanisms to build resilience towards the adverse consequences caused by climate change. A review of the unpublished Disaster Management Plans of some of the assemblies in the Bono Region revealed that: There are increasing heat waves, incidence of flooding, and bushfires. These disaster management plans gave basis to the research problem which is the ineffective integration of spatial planning strategies into disaster resilience. The research topic was searched in Google Scholar and published in or Perish database which resulted in a research gap in this study.

Materials and Methods

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 (Swanborn, 2010). 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. Instruments were prepared to identify and gather relevant spatial planning strategies datasets for the study area, including laws and policies applied in administering land in Ghana and geographic data layers such as study area boundary maps, environmental features, and socioeconomic

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indicators. This questionnaire was administered at the Physical Planning Office, Works Engineers, Development Planning Office, and Lands Commission Office in the Bono Region. However, 677 household or citizen questionnaires were administered to gather primary information for analysis of spatial planning strategies in reducing disaster occurrence in the study area. Previous case studies of cities or urban regions that have successfully integrated spatial planning strategies for robust disaster resilience are highlighted in the literature review. Bono Region was purposely selected for this research to investigate the application of spatial planning strategies in developing resilience against disaster occurrence. The rationale for selecting the Bono Region is to assist in analyzing the correlation between disaster resilience and spatial planning strategies. Which qualifies this research as a descriptive one. Units of inquiry are the developers and citizens. In determining the spatial extent and scale of the study area, Fig. (1) is presented. The Bono Region share borders with the Savanna Region to the north, the Bono East Region to the east, the Ahafo Region to the south, and the Western North Region to the west. Additionally, the Ghana-Cote D'Ivoire International Border borders the area to the west. The Bono Region covers an area of approximately 11,481 km^2. (4433sqmi). around 369 km separates the national and regional capitals, resulting in an average travel duration of 7 h and 50 min.

The Ghana Statistical Service's 2021 population and housing census indicates that 1,208,649 people live in the Bono Region overall. The population distribution by sex shows that 611,973 women make up 50.6% of the population, while 596,676 men make up 49.4%. Between 2010 and 2021, the region's interdental population growth rate was 2.5, (Service, 2021). Twelve administrative districts make up the Bono Region; six (6) are municipalities and the remaining six (6) are districts. 529,590 people live in these districts and municipal capitals, making up the sample frame. The calculations provided by:

n□N / (1□N(a)²)

where: “a” is the margin of error

“N” is the sample frame and

“n” is the sample size

Was used to determine the sample size for this study (Morey, 2008). Adding this to the equations for determining sample size:

n□ 3,573/1□3,573(0.1)2 n□ 3,573/1□3,573(0.01)

n□ 3,573/1□35.73

n□ 3,573/ 36.73 n□ 97.28

Fig. 1: Map of the study area

This process was applied to the other eleven District and Municipal Capitals respectively to determine their sample size which cumulatively yielded 1,392.31 as the sample size for the household questionnaire in this research. Although, the sample size is 1,392.31. It is therefore assumed that achieving 60% of the questionnaire administered given by: (60/100□1, 392.31 = 835.39) can be used for triangulation. The total number of questionnaires administered was 667 which is demonstrated in Fig. (2). Data collection is the stage of research where the subjects are approached and the information required for the research is gathered. Data collection in case study research is accomplished using methods defined in the case study protocol (Yin, 2009). Therefore, the primary source of data was collected through questionnaire administration. This approach facilitated the interaction with respondents in a guided manner which enhanced their understanding of the complexities of spatial

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planning implications on disaster resilience. Secondary data was also collected through a literature review of relevant and related articles, reports, and other legislative documents. The research was based on quantitative data collected from land sector agencies at both district and regional levels, estate developers as well as city dwellers in the Bono Region. Resident respondents were sampled using the simple random sampling technique, while land sector agencies and other related institutions were purposively sampled. A structured questionnaire was primarily used to collect data from households while an interview guide was primarily adopted to collect data from institutions. The decision on the number of questionnaires administered to city dwellers was guided by the sampling frame. In this research, 12 administrative districts were considered. Bono Region has several urban centers but for this research, the municipal/district capitals were focused on drawing empirical evidence and making recommendations to improve upon land administration. The questionnaires were administered using the Kobo Toolbox software (Poloju et al., 2022). The unit of analysis refers to the actual empirical units, objects, and occurrences that must be observed or measured to study a particular phenomenon, and having defined the problem to be investigated, it is important to identify how the problem will be measured. This will point out the key factors for decision-making about the appropriate unit of analysis the researcher wants to discuss and draw inferences and conclusions at the end of the research.

The research is based on two main units of analysis, the first one is an examination of processes for spatial planning strategies and disaster resilience in the Bono Region. Consequently, the data from various sources notably land sector agencies, private sector institutions, and city dwellers in the Bono Region were collated, analyzed, and synthesized. Inferences and conclusions were obtained based on qualitative approaches and relevant statistical software packages such as Statistical Package for Social Scientists (SPSS) version 16 and Microsoft Excel were used for data analysis.

Results and Discussion

Synthesizing the findings from the data collected from institutions and citizens in the Bono Region, tabulation was made from the responses captured from the administered questionnaire. The processing of tables was

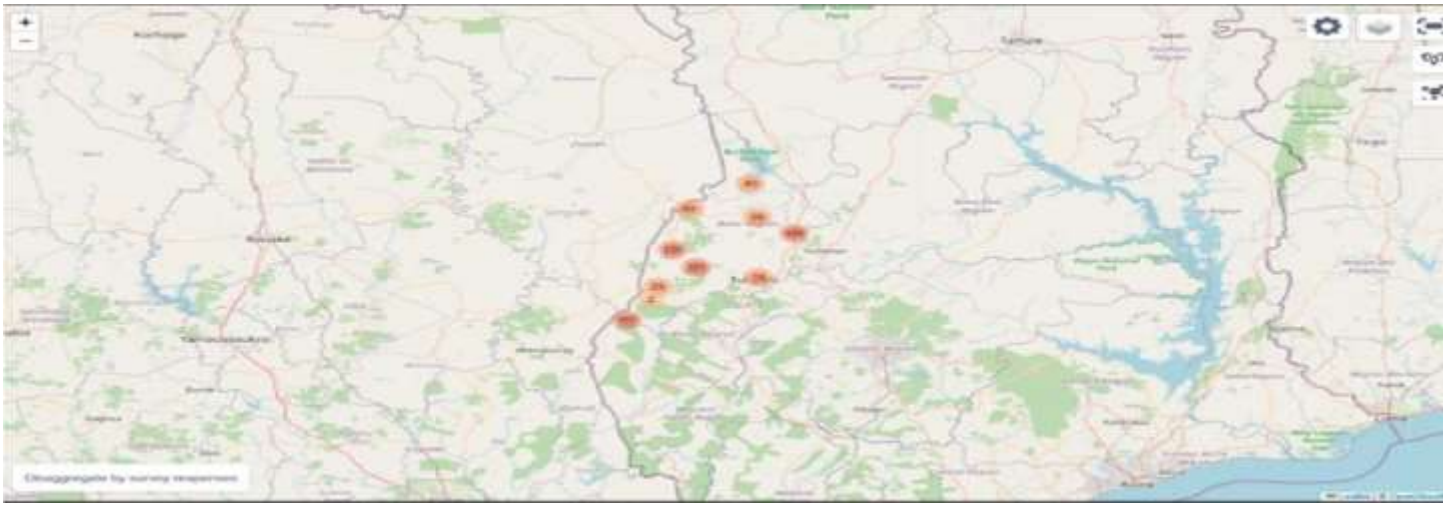

Fig. 2: Geo-locational map of questionnaire administered

analyzed using an Excel sheet to produce pie charts and histograms to aid in evaluating the extent of community

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resilience through spatial planning strategies by comparing outcomes, processes, and decision-making after the implementation of spatial planning strategies. The outcomes of the primary data captured are demonstrated below. The effectiveness of land regulations invariably affects a community's disaster resilience as a gross violation of building regulations and laws leads to vulnerability or exposure to disaster occurrence. The effectiveness of land Regulations can be assessed through the ability of law enforcement agencies to enforce these regulations and laws by the requirements of these laws. The effectiveness of regulations determines the ability to withstand disaster occurrence as law enforcement agencies are responsible for controlling physical developments to avoid unauthorized developments in inappropriate spaces that cause disasters. As depicted in Fig. (3), the largest segment of respondents, accounting for 41%, demonstrates medium compliance. This indicates that the majority of the population demonstrates a moderate level of adherence to building regulations and laws as indicated in Fig. (5). The combined low and very low compliance levels account for 35% (26+9% respectively), indicating that slightly more than one-third of citizens experience low to very low compliance. On the other hand, a relatively small percentage of the population complies closely with building regulations and laws, which is counterproductive to disaster resilience and requires the implementation of effective enforcement strategies. Together, the high and very high compliance levels account for 24% of the total (11+13%, respectively). Canada's municipal-level building permit system, overseen by cities like Toronto and Vancouver, ensures compliance with regulations, promoting safety and sustainability in construction. These results relate to the research objective on the promotion of land use policies that seek to mitigate the impact of risk, such as controlling development in high-risk, fostering collaboration among community members, Chile, after the 2010 earthquake and tsunami, Chile has improved its spatial planning strategies to enhance disaster resilience. This includes the implementation of stricter building codes and land use policies to prevent construction in high-risk areas.

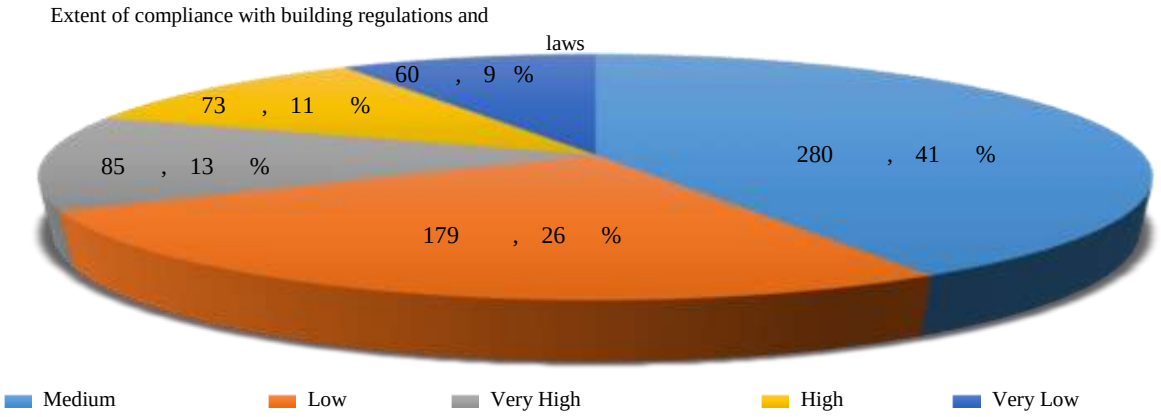

Fig. 3: Extent of compliance with building regulations and law

Land information on the topographical landscape of an area is an important determinant in predicting the risk level in a particular geographical area. To create exact hazard maps and identify places vulnerable to natural catastrophes like floods, earthquakes, landslides, and wildfires, precise and accurate land information is necessary. Authorities can evaluate the susceptibility of communities, infrastructure, and vital utilities to different disasters by using extensive land data. Zoning laws and land use plans that reduce the risk of disasters, including prohibiting buildings in high-risk locations, may be developed with the use of accurate land information. The efficacy of early warning systems for catastrophes can be increased by combining precise land information with up-to-date

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environmental data. To create evidence-based policies that improve catastrophe resilience, policymakers may utilize correct land information.

From Fig. (4), a medium score of 41.06% was obtained from the respondents while the combined percentage for high and very high is 24.07%

(11.37+12.7%, respectively). This means that for high and very, slightly less than 25% of respondents acknowledged accessibility and accuracy of land information. Conversely, 68.09% is a combined score for low and very low (27.03+41.06% respectively), which buttresses the fact that almost 70% of respondents indicated low and very low accessibility and accuracy of land information. These results relate to the research objective of governmental and non-governmental agencies to ensure a strategic approach to disaster resilience through information sharing.

To strategize against disaster occurrence in the study region and across the globe, synergies must be built to improve the accessibility and accuracy of land information. In contrast to this result, Australia's National Geographic Data Infrastructure (NSDI) guarantees that geographic data is easily obtainable and compatible, increasing its usefulness for disaster risk reduction. Through enhanced accessibility and accuracy of land information, stakeholders at all levels, from local communities to national governments can increase overall resilience by better predicting, planning for, responding to, and recovering from calamities.

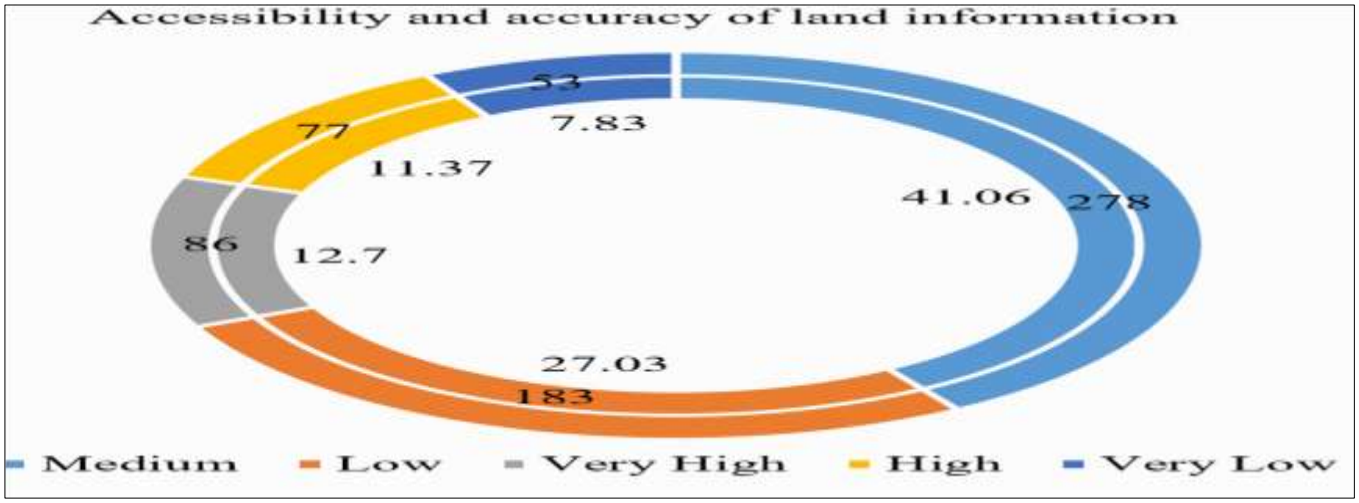

Fig . 4 : Accessibility and accuracy of land information

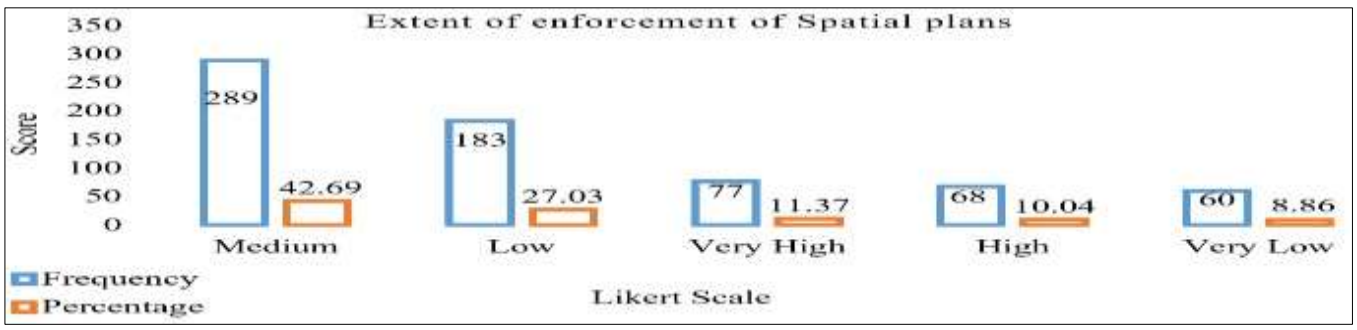

Fig . 5 : Extent of enforcement of spatial plan s

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Spatial plans regulate how land should be put to use. The extent of enforcement of spatial plans determines how land governance mechanisms work to achieve results. Inferring from Fig. (5), the percentage score for the medium is 42.69%. However, high and very high is 21.41% (10.04+11.37% respectively). Indicating that less than a quarter of respondents think that spatial plans are implemented successfully. Conversely, combined percentage scores of low and very low scores are 35% (27.03+8.86%) indicating that there is low enforcement of spatial plans. Combined low enforcement of spatial plans implies that initiatives such as strengthening collaboration with allodial and usufruct owners assist in the smooth implementation of approved spatial plans as a means to reduce disaster occurrence. These results relate to the research objective on the promotion of land use policies that seek to mitigate the impact of risk, such as controlling development in high, to foster collaboration among community members.

The Netherlands employs sophisticated spatial planning strategies to manage flood risks, including the "Room for the River" program, which involves redesigning river landscapes to accommodate higher water levels and reduce flood risks. Urban governance institutions' preparedness and functionality in delivering according to their mandate enshrined in governing laws indicates how land administration is delivered. From Fig. (6), it can be deduced that the percentage score in the medium is 35.16%. However, high and very high is 22.15% (8.71+13.44% respectively). Conversely, low and very low percentage scores are 42.68% (34.56+8.12% respectively) which implies that almost half of the respondents indicated low and very low effectiveness of urban governance institutions. These results relate to the research objective on the promotion of land use policies that seek to mitigate the impact of risk, such as controlling development in high, to foster collaboration among community members.

This scenario does not auger well for robust resilience against disaster occurrence. Comparing this, Singapore's efficient land governance and administration system is driven by its highly digitalized approach and use of Spatial Data Infrastructures (SDI). Access to information and civic engagement play a crucial role in reducing disasters as every simulation exercise on disaster demands information sharing and citizenry engagement in the form of community forums and public durbars discourse. Figure (7) shows 38.55% as a medium. Combined high and very high is 20.97% (8.86+12.11% respectively). On the other hand, low and very low percentage scores are 33.53 and 6.94 respectively, which cumulatively is 40.47%. 59.52% of those interviewed responded that there is moderate to very high access to information which positive outcome, however, there is a significant proportion of the interviewers constituting 40.47% indicated that there is low and very low access to information and civic engagement which for calls rectification in the study region to boost disaster resilience. These results relate to the research objective of governmental and nongovernmental agencies to ensure a strategic approach to disaster resilience through information sharing.

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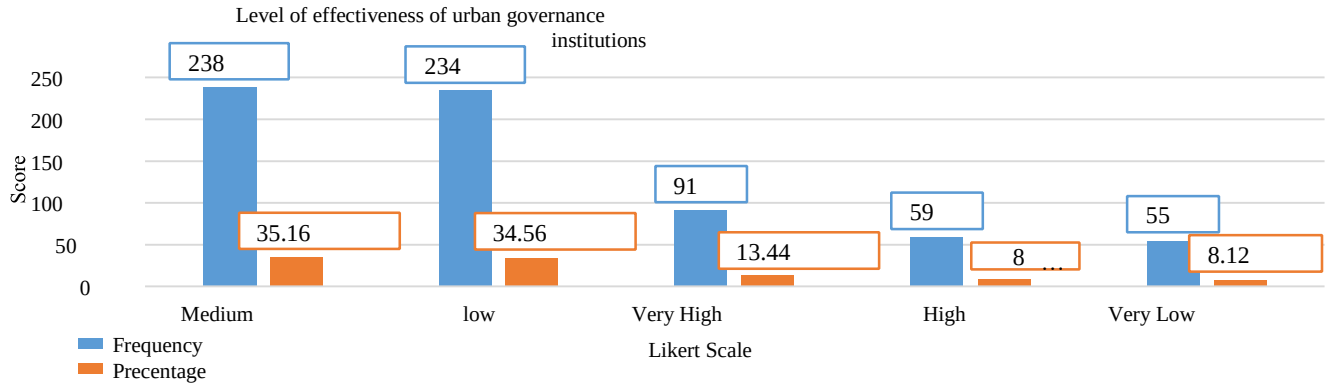

Fig . 6 : Level of effectiveness of urban governance in stitutions

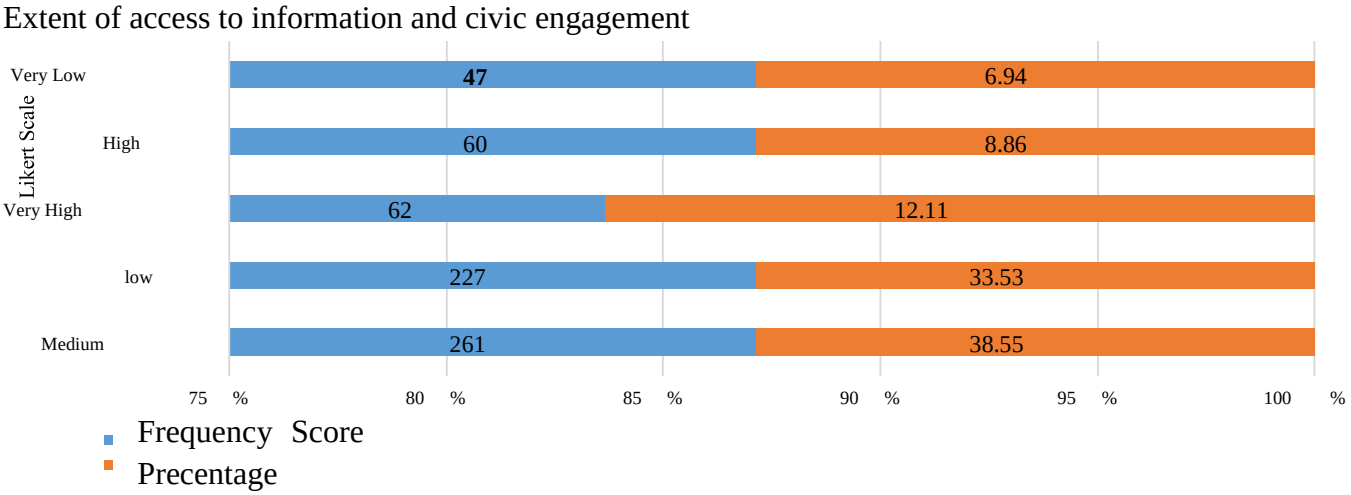

Fig. 7: Extent of access to information and civic engagement

Comparatively, the Federal Office of Civil Protection and Disaster Assistance (BBK) in Germany offers up-todate information on different dangers along with comprehensive instructions. Apps for warnings like NINA facilitate the rapid dissemination of information. Civic Engagement: Local disaster response teams and olunteer fire brigades are important components of preparedness and response for emergencies. Training workshops and public awareness initiatives are periodically held. Digital connectivity and access to Information and munication Technologies (ICT) provide adequate signals for strategizing against the occurrence of disasters. Most disaster cases are dealt with through early warning signals which are dealt with through digital platforms and nnectivity. Figure (8) indicates that the medium score is 35.3%. Combined high and very high is 27.77% (10.64+17.13% respectively). On the other hand, low and very low summation is 36.8% (28.8+8% respectively). This implies that 36.8% of those interviewed responded that there is digital connectivity and access to information and communication technologies, however, there is a significant proportion of the respondents constituting 28.8% indicated that there is low and very low access to digital connectivity and access to information and communication technologies which calls for rectification in the study region to boost disaster resilience. These results relate to the research objective of governmental and nongovernmental agencies to ensure a strategic

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approach to disaster resilience through information sharing. With enormous fiber-optic networks and widespread mobile internet use, Japan has one of the world's fastest and most dependable internet infrastructures in terms of digital connection. In addition, the Japanese people have access to high-speed internet and the government has made large investments in digital education and infrastructure. With the use of mobile networks and applications, Japan employs advanced early warning systems for earthquakes and tsunamis. Up-to-date and comprehensive information on hazards is made available by the Japan Meteorological Agency and other authorities. Geographic Information Systems (GIS) assist in providing geospatial data about disaster-prone locations for strategic spatial planning to curb if not completely eradicate disaster occurrence. Examining the Level of the contribution of GIS to promoting collaboration among stakeholders in Fig. (9), it can be deduced that, the medium score is 32.35%. However, high and very high scores are 33.97% (8.71+25.26% respectively). However, low and very low percentage scores are 33.68% (26.59+7.09% respectively). This implies that 33.68% of the respondents agreed that there is a low and very low level of GIS awareness of the use of GIS technologies which needs improvement to promote the level of awareness of the GIS technologies among the general public in building disaster resilience. These results relate to the research objective of the establishment of mechanisms for monitoring and evaluation of disaster resilience measures based on lessons learned.

Extent of digital connectivity and access to information and communication technologies

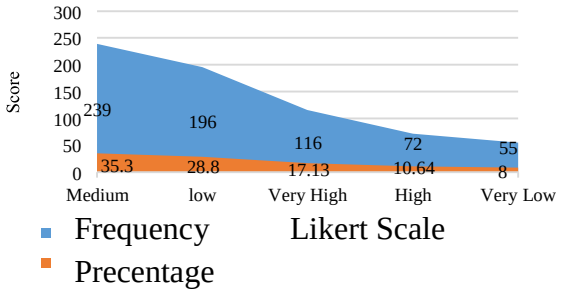

Fig. 8: Extent of digital connectivity and access to information and communication technologies

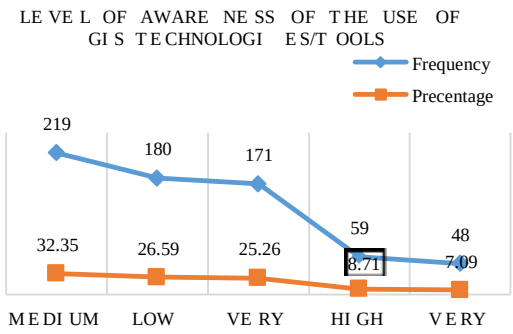

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Fig. 9: Level of awareness of the use of GIS technologies/tools

Canada, in contrast, employs GIS for a range of disaster management tasks, such as mapping floods, tracking wildfires, and estimating the risk of earthquakes. GIS is being used extensively by Natural Resources Canada

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(NRCan) to increase resilience to disasters. The charting of flood-prone regions, seismic event preparation, and wildfire monitoring are all made easier in Canada by GIS applications. Resources for disaster management that offer real-time data include the Canadian Wildland Fire Information System (CWFIS). Through the simulation of diverse disaster scenarios, GIS facilitates the development of comprehensive emergency response plans. The technology enables precise planning of emergency shelter locations, evacuation routes, and resource allocation. This spatial analysis ensures that emergency services are wellprepared, allowing them to respond promptly and efficiently. From Fig. (10), it can be deduced that the percentage score in the medium is 31.16%. However, a high and very high score is 34.71% (8.71+26%, respectively). Conversely, low and very low percentage score is 34.12% (27.92+8.12%, respectively). 34.12% of respondents scoring low and very low for level of knowledge in using GIS technologies implies that most of the respondents do not have adequate knowledge in GIS as expected which requires improvement to be abreast with disaster alerts and prompts. These results relate to the research objective to establish mechanisms for monitoring and evaluation of disaster resilience measures based on lessons learned. In contrast, Germany is a leader in the use of GIS for flood control, especially along the Rhine and other large rivers. The nation has many university programs devoted to geospatial technology and incorporates GIS into its national disaster management strategy.

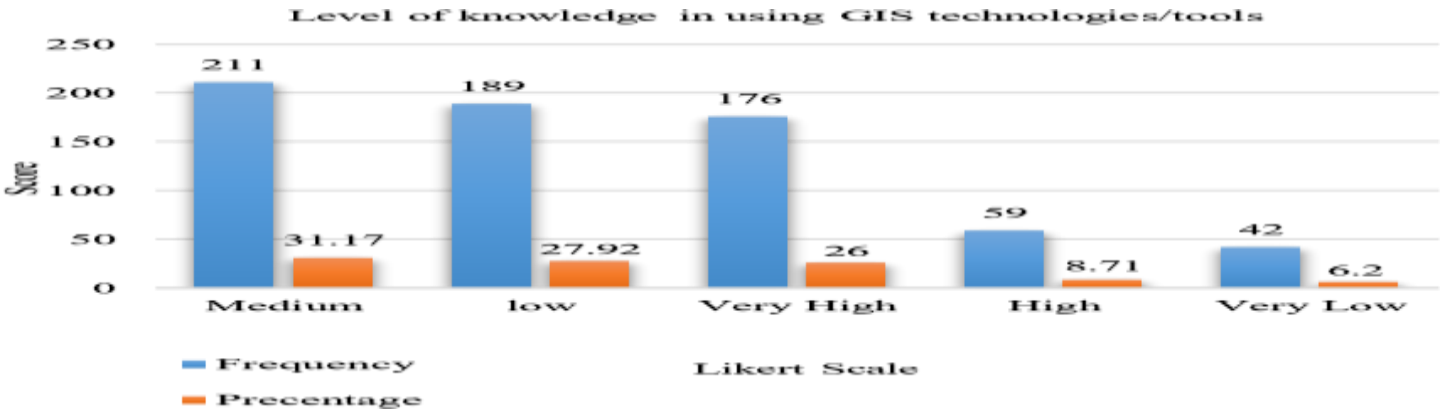

Fig. 10: Level of knowledge in using GIS technologies/tools Disaster management is neither the responsibility of an individual nor an institution which calls for collaboration among actors to solve disasters anytime they occur. Geographic Information Systems (GIS) provide a common platform for data integration, real-time information sharing, and coordinated decision-making, which are essential for fostering collaboration among stakeholders in disaster resilience. Examining the Level of the contribution of GIS to promoting collaboration among stakeholders from Fig. (11), it can be deduced that, the medium score is 27.92%. However, high and very high scores are 12.4% (7.53+4.87% respectively). However, low and very low percentage scores are 59.67% (34.12+25.55% respectively). This implies that 59.67 % of the respondents agreed that there is a low and very low level of the contribution of GIS to promoting collaboration among stakeholders which needs massive improvement to promote collaboration among stakeholders in responding to disasters. These results relate to the research objective on the promotion of land use policies that seek to mitigate the impact of risk, such as controlling development in high, to foster collaboration among community members. Bangladesh has used spatial planning and geospatial techniques to enhance flood resilience in urban areas, particularly in Dhaka. Strategies include improved drainage systems and the creation of flood retention basins. To enhance disaster resilience, it is essential to integrate smart

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infrastructure into metropolitan areas. Through the deployment of automated response systems, monitoring mechanisms, and advanced communication technologies, smart infrastructure significantly improves the capacity for prompt and sustainable disaster response over the long term.

L E VE L O F C O N T R I B UT I O N O F G I S T O PR O MO T I N G C O L L AB O R AT I O N AMO N G ST AKE H O L D E R S

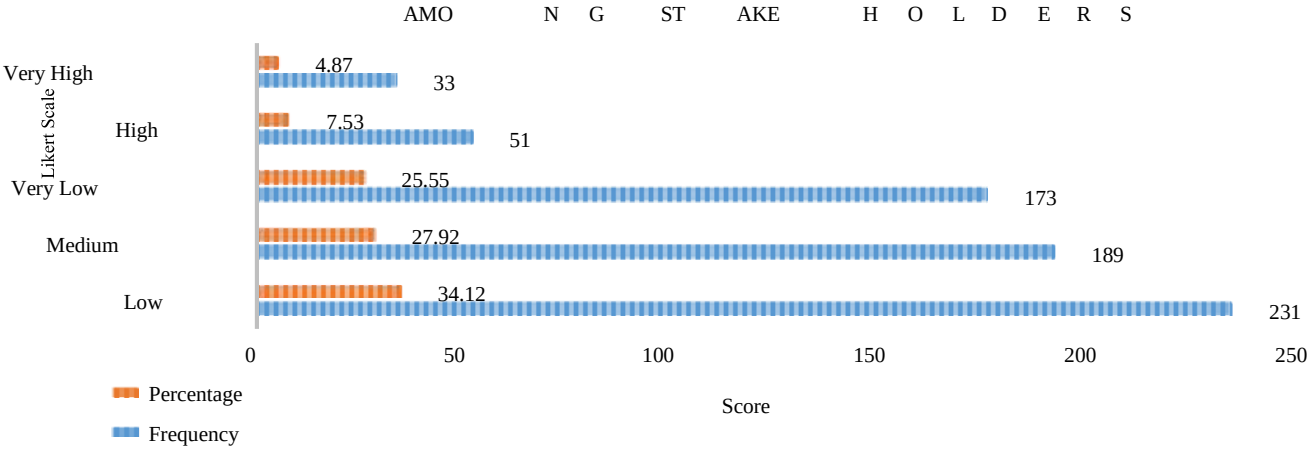

Fig. 11: Level of the contribution of GIS to promoting collaboration among stakeholders

Inferring from Fig. (12), the percentage score for the medium is 32.64%. However, high and very high is 15.22% (8.57+6.65% respectively). Indicating that less than a quarter of respondents think that there is a high level of infrastructure smartness. Conversely, combined percentage scores of low and very low scores are 52.14% (37.96+14.18%) indicating that there is low-level infrastructure smartness. A combined low level of infrastructure smartness implies that initiatives such as investing in smart infrastructure improve disaster resilience. These results relate to the research objective of the establishment of mechanisms for monitoring and evaluation of disaster resilience measures based on lessons learned. In South Korea, real-time monitoring systems, IoT sensors, and smart city infrastructure are utilized. Smart grids provide a steady power supply during crises and Internet of Things (IoT) sensors are used in South Korean cities like Seoul to monitor the infrastructure. From Fig. (13), the study identified that 62.8% of respondents disagreed about the ability of community resilience, while 37.2% agreed, indicating that 62.8% of respondents believe that communities do not have the ability for disaster resilience.

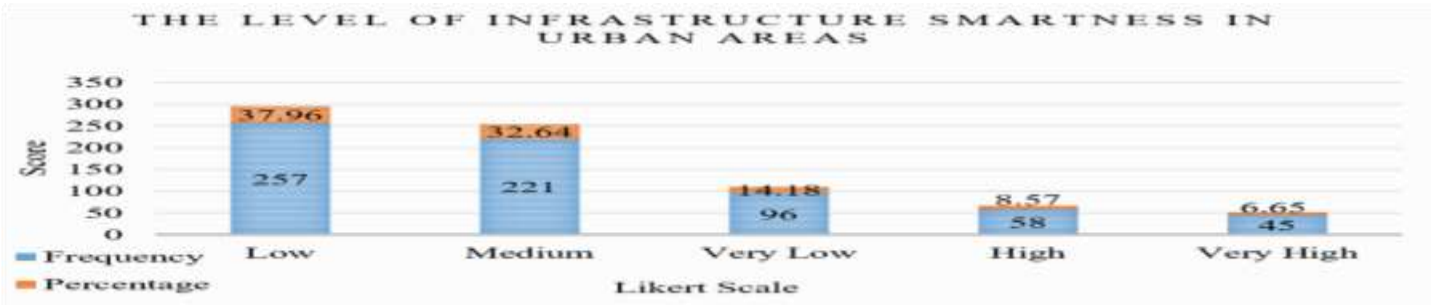

Fig. 12: The level of infrastructure smartness in urban areas

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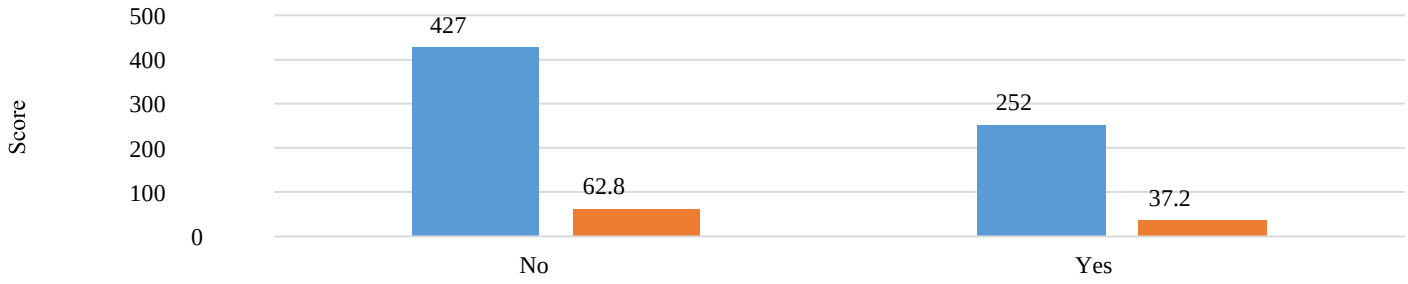

Fig. 13: Extent of awareness of land policies

Hypothesis Testing

The study is guided by the following hypothesis:

H_0 = Effective spatial planning promotes disaster resilience

H_1 = Effective spatial planning strategies do not promote disaster resilience

The Mann-Whitney U Test statistical approach is demonstrated in a real-world scenario using the statistical software SPSS (Arkkelin, 2014), to help with understanding. Data processing, group median computation, study result interpretation, and determining the degree of effect among the crossing variables are some of its applications (Milenović, 2011). Independent samples Whitney-Mamann U Tests offer a rigorous analytical foundation for comprehending the connection between sustainable land administration characteristics and the efficacy of land governance, with consequences for rejecting null hypotheses. We reject the null hypothesis and conclude that there is insufficient scientific evidence to reject the alternative hypothesis if the p-value is less than 0.050. Table (1), the efficacy of disaster resilience in the research region is distributed uniformly across the spatial planning parameters. This implies that efficient Urban Resilience and spatial planning parameters are related. The ordinal regression model result indicates there is a significant relationship between effective urban resilience and spatial planning parameters, where spatial planning parameters explain about 58% of effective urban resilience (Pseudo R-squared values = 0.587) as indicated in Table (3). This suggests that the model is reasonably effective in predicting the different levels of effective urban resilience based on spatial planning parameters. Consequently, we fail to reject the null hypothesis which states that effective spatial planning promotes disaster resilience. Subsequently, the absence of effective urban resilience, as indicated by 62.8% of respondents can be explained by the poor performance of spatial planning parameters in the study area. Table (2) is the output from an ordinal regression model, where the goodness-of-fit statistics assess how well the model fits the observed data.

Turhan (2020) postulates that statistical tests have been an important tool for interpreting the results of research correctly. The factors that influence the determination of the statistical test are research purpose, hypothesis, and data. Today, statistical tests are used more frequently and they aim to analyze whether statistical tests are used in accordance with research. This statistic (537.089) compares the observed and expected frequencies under the model. The degree of freedom (df) is 517 and the significance level (Sig.) is 0.262. Since the p-value is greater than 0.05, there is no significant evidence to suggest a poor fit, indicating that the model fits the data reasonably well.

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Table 1: Mann-Whitney U Test (Nonparametric Tests)

Hypothesis Test Summary				
NO.	Null Hypothesis	Test	Sig. a,b	Decision
1	The distribution of 2. The extent of compliance with building regulations and laws is the same across categories 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
2	The distribution of 3. Accessibility and accuracy of land information are the same across categories of 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
3	The distribution of 4. Extent of enforcement of Spatial plans. Is the same across categories of 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
4	The distribution of 5. The level of effectiveness of urban governance institutions is the same across categories of 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
5	The distribution of 6. The extent of access to information and civic engagement is the same across categories 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
6	The distribution of 7. The extent of digital connectivity and access to information and communication technologies (ICTs) is the same across categories of 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
7	The distribution of 8. The level of awareness of the use of GIS technologies/tools is the same across categories of 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
8	The distribution of 9. The level of knowledge in using GIS technologies/tools is the same across categories of 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
9	The distribution of 10. The level of the contribution of GIS to promoting collaboration among stakeholders is the same across categories of 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis

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10	The distribution of 11. The level of infrastructure smartness in urban areas is the same across categories 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
11	The distribution of 12. The level of patronage in the use of GIS for navigation in urban areas is the same across categories of 1. The ability of the community in disaster resilience	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis
a. The significance level is .050				
b. Asymptotic significance is displayed				

Table 2: Goodness of fit

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	537.089	517	.262
Deviance	473.948	517	.913
Link function: Logit			

Table 3: Pseudo R-square

Pseudo R-Square	
Cox and Snell	.430
Nagelkerke	.587
McFadden	.426
Link function: Logit	

Deviance: This is another measure of goodness-of-fit, with a value of 473.948 and the same degrees of freedom (517). The p-value here is 0.913, also well above 0.05, further suggesting that the model is a good fit. Overall, both tests suggest that the ordinal regression model adequately fits the data. The poor degree of spatial planning strategies that was discovered is further supported by the 62.8% of respondents who indicated that there is inadequate ability for disaster resilience within the research region in the previous conversations. For this reason, we are unable to reject the null hypothesis of the study, which holds that spatial planning strategies enhance disaster resilience given the documented relationship between the two as explained in Table (3).

Conclusion

Developing communities that can endure and recover from both natural and man-made hazards requires enhancing disaster resilience through spatial design strategies. To support data-driven decision-making, stakeholder cooperation, and proactive risk management, spatial planning which makes use of tools like Geographic Information Systems (GIS) is essential to this process. Communities may strategically allocate resources, create efficient evacuation routes, and define safe zones for shelters and essential infrastructure by incorporating spatial planning into disaster resilience strategies. In particular, GIS technology offers a strong foundation for organizing emergency response activities across several stakeholders, tracking environmental changes in realtime, and visualizing risk situations. This integration promotes long-term recovery and sustainability in addition to improving response times. In addition, socioeconomic data and climate change estimates can be included in spatial planning methods to guarantee inclusive and equitable resilience measures. Participating local communities in the

planning phase increases the efficacy and applicability of resilience solutions while encouraging collaboration and a sense of ownership. In summary, the implementation of spatial planning techniques, supported by cutting-edge technology such as GIS, is essential for augmenting disaster resilience. Communities may greatly lessen their susceptibility to disasters and improve their ability to recover quickly and sustainably by implementing a comprehensive strategy that includes risk assessment, stakeholder collaboration, and ongoing monitoring. Spatial planning strategies play a critical role in enhancing disaster resilience by reducing vulnerabilities and ensuring that communities are better prepared for catastrophes. Hazard assessment, land use planning, infrastructure resilience, community involvement, and policy integration can all be combined to significantly improve an urban area's capacity to withstand and recover from disaster events. To support the collaborative effort that government agencies, businesses, and local communities must make to accomplish these goals, strong data and state-of-the-art technologies are required.

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