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EFFECTIVENESS OF ENVIRONMENTAL IMPACT ASSESSMENT (EIA) IN URBAN DEVELOPMENT: A CASE OF QUETTA METROPOLITAN CITY, PAKISTAN

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Abstract

This research investigates the effectiveness of Environmental Impact Assessments (EIA) in managing urban development, with a specific focus on Quetta, Pakistan. Quetta has faced rapid urbanization and significant demographic shifts, posing considerable socio-economic and environmental challenges. The study employs a mixed-method approach, including public perception surveys, demographic analysis, infrastructure and service evaluation, and land use and land cover change analysis using Landsat satellite imagery and GIS tools. Key findings indicate a diverse population with varying educational backgrounds and significant concerns regarding basic amenities such as clean drinking water, sanitation facilities, and waste management systems. The public perception survey reveals that 65.8% of participants have access to clean drinking water and sanitation, but a notable 34.2% do not. Additionally, 67.9% of communities lack organized waste management systems. Awareness of key development authorities, such as the Quetta Development Authority (QDA) and the Balochistan Development Authority (BDA), is moderate, with 52.7% and 49.4% awareness, respectively. The land use and land cover change analysis highlights substantial urban expansion, underscoring the urgency for sustainable development practices. Despite the implementation of EIAs, their effectiveness is constrained by regulatory and enforcement challenges, as evidenced by the ongoing environmental issues such as poor waste management and high pollution levels. The study concludes that while EIAs are critical for identifying and mitigating environmental impacts, their efficacy in Quetta is limited. Enhancing the effectiveness of EIAs requires robust governance, improved infrastructure, and increased community engagement. This research underscores the need for integrating environmental, social, and economic considerations into urban planning to achieve sustainable development outcomes. By addressing the identified gaps, the study aims to contribute to more effective urban planning and environmental management in rapidly urbanizing cities like Quetta.

Keywords: Urban Planning, Sustainable Development, Pollution, GIS.

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1. INTRODUCTION

Human well-being is intricately linked with environmental sustainability. All facets of human development, including infrastructure construction, influence the natural environment, and vice versa. Numerous tools assist developers, builders, and policymakers in understanding this crucial interplay between urban development and the natural ecosystem. One such tool is the Environmental Impact Assessment (EIA). An Environmental Impact Assessment (EIA) is a project-specific tool used to identify and assess the actual and potential environmental impacts of a project before it commences [1]. The primary aim of EIAs is to provide decision-makers with information regarding potential consequences that may arise from new projects, programs, plans, or policies. EIAs are applied to foresee the effects of development projects and serve as a primary tool for environmental management to ensure the minimization, avoidance, or rehabilitation of impacts. This process contributes to environmentally sound decision-making and the design and construction of acceptable developments [2].

In the current era, it is generally expected that Impact Assessment (IA) is a critical component of decision-making about infrastructure planning [3] It is rare for megaprojects to be approved and implemented without mandatory EIAs. Most international agencies, multilateral donors, lenders, and industries now require integrated Environmental and Social Impact Assessments (ESIA) that evaluate the effects of the projects they sponsor and capture the interrelationships between society and the impacted environment [4].

Environmental Impact Assessments have been used for over half a century and are now applied in most countries worldwide. They help in evaluating different decisions before planning any development or project and safeguard better development outcomes [5]. While EIAs play an essential role in making proposed developments environmentally acceptable, their effectiveness has been debated for many decades [6].

The EIA/ESIA concept has evolved since its origins in the USA in the late 1960s [7]. By the early 1990s, over 40 countries had implemented EIA legislation. EIA has since become generally required in all developing countries because development banks require EIAs for projects considering financing. Although stated ESIA procedures are generally similar worldwide, the quality of application varies greatly [8].

Uncontrolled and rapid urbanization in developing countries results in serious development challenges. According to a United Nations report [9](UN, 2014), by 2050, 66% of the world's population will dwell in urban areas. This rapid expansion presents environmental challenges and opportunities for urban development that can enhance overall well-being and contribute to global sustainability objectives. Currently, half of the world's population resides in urban regions, with increasing numbers living in towns and cities in low and middle-income nations. Urban areas are crucial for social and economic progress, offering platforms for social and cultural events, and advancements in science, technology, and education [10].

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Quetta, the capital of Balochistan, has experienced significant growth and challenges due to rapid urbanization and the influx of Afghan refugees. Once a small town until 1947, Quetta has transformed into a heavily populated city, straining its resources, environment, infrastructure, and socio-economic conditions. The city's urban area includes the Quetta Municipal Corporation and the Quetta Cantonment, with significant urban demography, economy, and politics. Quetta is the largest consumer of natural resources in Balochistan, posing serious environmental challenges for future generations. This research aims to present the effective of EIA in uraban development in Queta city. It aims to provide insights and recommendations for controlled and sustainable development to policymakers.

2. METHODOLOGY

2.1. Study Area

The research focuses on the effectiveness of Environmental Impact Assessments (EIA) in urbanization, specifically in Quetta, the capital city of Balochistan, Pakistan. Quetta, the capital of Balochistan and the 10th largest city in Pakistan, has faced significant challenges due to rapid urbanization and the influx of Afghan refugees, which have strained its socio-economic and environmental conditions. As of the 2017 census, Quetta's population stands at approximately 2.3 million. The city is geographically bounded by Pishin to the north, Mastung to the south, Harnai to the east, and Afghanistan to the west. Situated at 30°11′N latitude and 67°00′E longitude, Quetta has a semi-arid climate with average summer temperatures between 23-25°C and winter temperatures around 4-5°C [11].

Administratively, Quetta is divided into two tehsils—Quetta City and Sadar—and one sub-tehsil, Punjpai. The city's terrain varies from 1390 meters to 3455 meters above sea level and is located in an earthquake-prone zone, with a notable earthquake in 1935 causing significant destruction. Urban expansion has been rapid over the past two decades, driven by both international and internal migration. The Quetta Development Authority (QDA), established in 1978, oversees urban planning and development [12]. Despite numerous development projects, the city's rapid growth necessitates updated master and development plans.

Quetta faces challenges such as inadequate urban policies, uncontrolled expansion, overlapping administrative roles, and ineffective building regulations, leading to overcrowding with a population density of approximately 286 persons per square kilometre. Effective environmental management, including Environmental Impact Assessments (EIAs), is crucial to mitigate environmental degradation and ensure sustainable development and biodiversity conservation [13]. The involvement of government officials, community members, and NGOs is essential for addressing these urban and environmental challenges.

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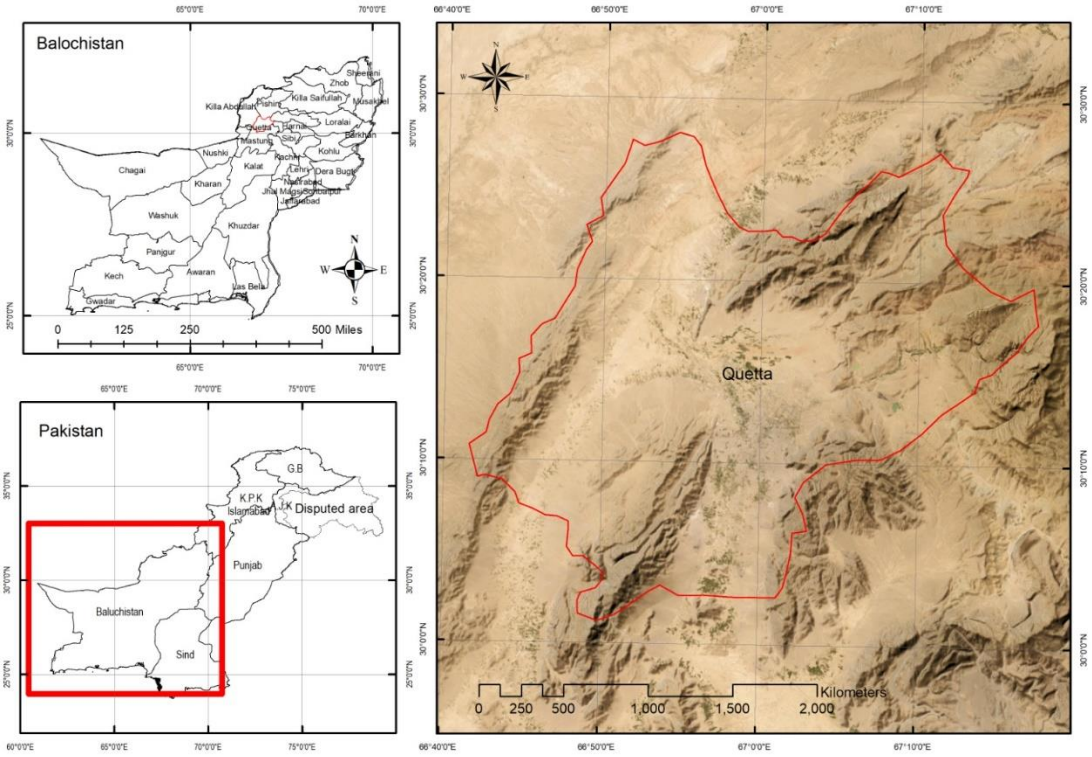

Figure 1: A map showing the location of the study area

2.2. Data Collection

Public Perception Survey

A questionnaire survey was conducted to gather public perceptions on various aspects of urbanization and EIA processes. The survey aimed to understand demographic characteristics and general awareness and attitudes towards EIA among the residents of Quetta. The questionnaire included questions on age, gender, education level, family size, and perceptions of environmental impacts of urbanization. This method is widely used in social science research to gauge public opinion and is well-documented in literature for its effectiveness in collecting primary data [5].

In this study, a sample of households was collected from Quetta city, Pakistan. The population and number of households were obtained from the latest census data [6]. To calculate the sample size for each district, 85% confidence and 5% margin of error were used. The population proportion was assumed to be 25%. Using these parameters, a sample of 384 households was collected using a formula for sample size calculation (Equation 1). The results show that the sample size is adequate to represent the population of each district and the percentage of households covered is within the acceptable range for a sample survey.

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$$SS = [Z^2p\ (1 - p)]/\ C^2$$

Equation 1

$$SS/\ [1 + \{(SS - 1)/Pop\}]$$

Where, SS = Sample size, Z = Given Z value, p = Percentage of population, C = Confidence level, and Pop = Population

EIA Project Data

Data on EIA projects conducted in Quetta city were obtained from the Environmental Protection Agency (EPA) Balochistan. This included detailed reports of various projects, their objectives, outcomes, and compliance levels [14]. The data also contained geographic coordinates of the project sites, which were essential for spatial analysis. Accessing secondary data from governmental agencies ensures the reliability and comprehensiveness of the information collected [15].

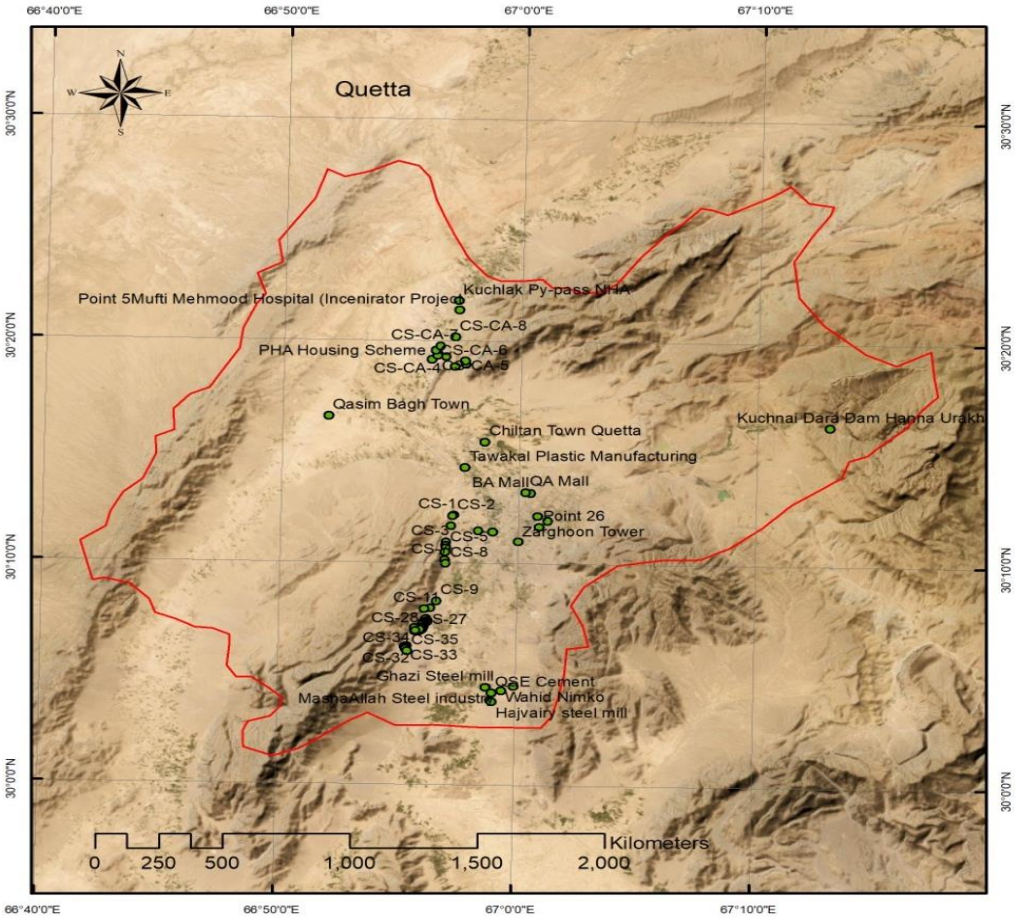

Figure 2: A map showing the locations of all EIA projects conducted in Quetta city

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Land Use and Land Cover Change Analysis

To assess the changes in land use and land cover (LULC) over time, Landsat satellite imagery was utilized.

The analysis was performed using Google Earth Engine, a cloud-based platform for planetary-scale environmental data analysis. This method allows for efficient processing and analysis of large datasets and is commonly used in environmental and urban studies [11].

2.3. Data Analysis

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was performed to reduce the dimensionality of the dataset and to identify the key variables that explain the most variance in the data. PCA is a statistical technique widely used in environmental and urban studies to simplify complex datasets and to highlight patterns [16].

K-means Cluster Analysis

K-means clustering was employed to classify the data into distinct groups based on their similarities. This method helps in identifying patterns and grouping similar data points, which is useful in understanding the spatial distribution of urbanization impacts and the effectiveness of EIAs. K-means clustering is a popular method in geographic and environmental research for its simplicity and effectiveness [17].

Mapping and Spatial Analysis

The geographic coordinates of EIA projects were used to create maps illustrating the spatial distribution of these projects across Quetta. Geographic Information System (GIS) software was utilized for this purpose, allowing for the visualization and analysis of spatial data. This approach is crucial for understanding the geographic context and the spatial relationships between different variables [18].

3. RESULTS AND DISCUSSIONS

3.1. Socioeconomic and Demographic Attributes

The age distribution of the participants reveals a diverse range, with the majority falling between 25 and 54 years old. Specifically, nearly half of the participants (46.7%) are aged 35-54 years, followed by 30.9% aged 25-34 years.

There is also notable representation from the younger adult demographic, with 11.5% aged 18-24 years. However, there's a decline in participation among older age groups, with only 6.4% aged 55-64 years and 4.5% aged 65 years and above (Table 1.).

In terms of gender distribution, the study predominantly comprises male participants, accounting for 78.8% of the sample. Female participants constitute the remaining 21.2% of the sample.

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This skew towards male representation in the study population could potentially influence the generalizability of findings, particularly if gender plays a significant role in the research context (Table 1). The educational attainment of participants varies widely, with the largest proportion (39.1%) holding a Master's degree, indicating a high level of education among respondents.

Following closely, 19.1% of participants have a Bachelor's degree, and 11.2% have completed an Associate's degree. Notably, a considerable portion of the sample (9.4%) reported having no formal education, suggesting diversity in educational backgrounds among participants. Additionally, smaller percentages are distributed across various educational levels, including Primary School, Middle School, Matric/High School, Intermediate Education, Vocational/Technical Certificate, and Doctorate/Ph.D.

This wide-ranging distribution underscores the importance of considering participants' educational backgrounds when interpreting study findings and drawing conclusions. Participants' family sizes also exhibit considerable variation, with the majority (57.0%) reporting households consisting of 7 or more people. Conversely, a smaller proportion (12.7%) indicated family sizes of 3-4 people.

The mean family size of 3.42 and the median of 4.00 suggest a tendency towards larger households, although there is some variability around this central tendency, as indicated by the standard deviation of 0.745. Regarding family structure, the data reveal that a significant majority of participants (62.4%) belong to Joint families, where multiple generations live together. In contrast, 37.6% of participants are part of Nuclear families, characterized by a single household consisting of parents and their children.

This distribution highlights the prevalence of Joint family setups within the study population and underscores the importance of considering family dynamics in research contexts where familial influences may be relevant (Table 1). The primary source of income for the participants exhibits diversity, with the majority (66.4%) reporting employment as their main source of income.

This indicates a significant portion of the population relying on salaries or wages from various employment opportunities. Additionally, a notable proportion (18.7%) are engaged in business or self-employment, reflecting entrepreneurial activities within the sample. A smaller percentage of participants (4.3%) derive their income from agriculture, highlighting the presence of individuals involved in farming or related activities. Furthermore, 10.7% report other sources of income, suggesting additional sources such as investments, pensions, or support from family members (Table 1).

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Table 1. Socioeconomic and demographic characteristics of the respondents.

Characteristics	Participant	No. and % age of respondents N = 330 (100 %)
Age	18-24 YEARS	38(11.5)
	25-34 YEARS	102(30.9)
	35-54 YEARS	154(46.7)
	55-64 YEARS	21(6.4)
	65 and above YEARS	15(4.5)
Gender	Male	260(78.8)
	Female	70(21.2)
Education	No Formal Education	31(9.4)
	Primary School	10(3)
	Middle School	9(2.7)
	Matric / High School	11(3.3)
	Intermediate Education (FA/FSC)	25(7.6)
	Vocational/Technical Certificate	3(0.9)
	Associate's Degree (BA or 14 Years Education)	37(11.2)
	Bachelor's Degree (16 years Education)	63(19.1)
	Master's Degree (18 Years Education)	129(39.1)
	Doctorate/Ph.D.	12(3.6)
Family Size	1-2 people	3(0.9)
	3-4 people	42(12.7)
	5-6 people	97(29.4)
	7 or more people	188(57)
Primary source of income	Employment	217(65.8)
	Business/self-employment	61(18.5)
	Agriculture	14(4.2)
	Other	38(11.51)

3.2. Basic Services and Environmental Conditions:

The assessment of access to clean drinking water and sanitation facilities revealed that a significant majority (65.8%) of participants enjoy reliable access to these essential services. Nevertheless, a considerable minority (34.2%) remain without such access, underscoring ongoing challenges in providing equitable clean water and sanitation coverage. Evaluations of road quality and infrastructure showed that 38.5% of respondents deemed these aspects poor, with another 33.9% considering them fair. Good quality ratings were reported by 21.5% of participants, while only a small fraction (4.2% and 1.8%) rated infrastructure as very good and excellent, respectively. In terms of environmental conditions, the perception of pollution levels was notably high, with most participants reporting moderate to severe air, water, and noise pollution in their neighbourhoods. The presence of green spaces was largely reported as insufficient, with 54.2% indicating very low levels and 30.5% identifying low levels, leaving only 15.5% of participants experiencing moderate to very high levels of green spaces. Finally, waste management services were predominantly rated poorly, with 58.2% of participants

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expressing dissatisfaction, 30.0% viewing the services as fair, and only 10.3% and 1.5% rating them as good and excellent, respectively. These findings highlight critical disparities and areas in need of improvement to enhance overall environmental and infrastructural conditions (Figure 3).

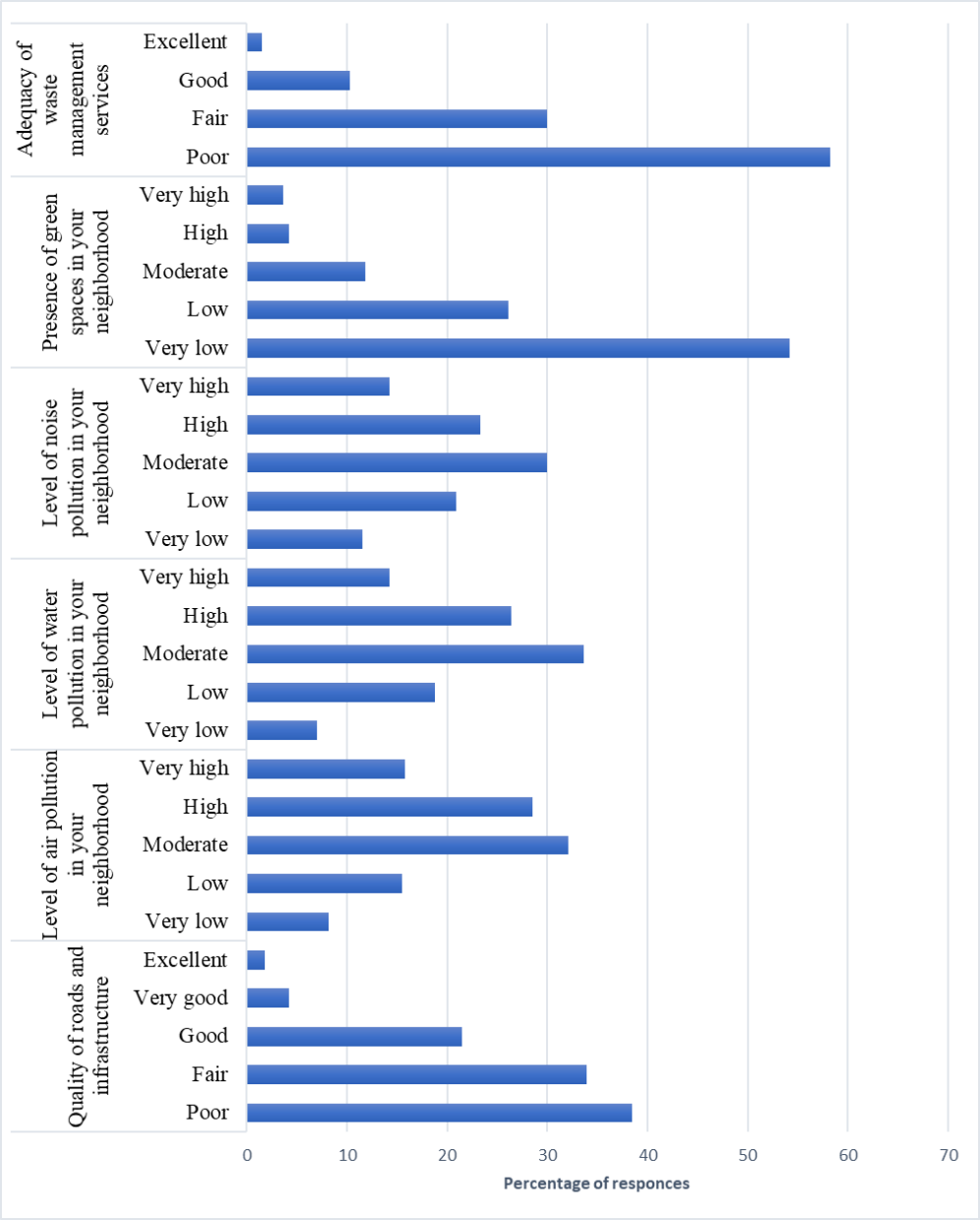

Figure 3: Basic Services and Environmental Conditions

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3.3. Social and Community Engagement:

Population Growth:

The majority of respondents (69.7%) perceive the current population growth in their district as rapid. This suggests significant demographic shifts and urbanization trends. However, a notable portion (19.7%) characterizes it as moderate, indicating a more gradual increase. A smaller percentage (4.5%) describes the growth as slow, while some respondents (6.1%) express uncertainty regarding the pace of population growth (Table 2).

Table 2: A table revealing the population growth in study area

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rapid	230	69.7	69.7	69.7
	Moderate	65	19.7	19.7	89.4
	Slow	15	4.5	4.5	93.9
	Not sure	20	6.1	6.1	100.0
	Total	330	100.0	100.0	

Waste Management Systems:

The data reveals that the majority of communities (67.9%) lack organized waste management systems, including regular waste collection and disposal services. A considerable portion (22.1%) reports irregular waste management practices, indicating inconsistencies in waste disposal efforts. Only a small percentage (10.0%) indicates the presence of proper waste management systems, reflecting a need for infrastructure development in this area (Table 3).

Table 3: Waste management systems in place in the community

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes, including regular waste collection and disposal	33	10.0	10.0	10.0
	Yes, but waste collection and disposal are irregular	73	22.1	22.1	32.1
	No, there is no organized waste management system	224	67.9	67.9	100.0
	Total	330	100.0	100.0	

3.4. Awareness of Development Authorities:

Quetta Development Authority (QDA):

Awareness: More than half (52.7%) of respondents are aware of the QDA and its role in urban planning and development in Quetta. This indicates a moderate level of awareness among the population. Lack of Awareness: However, nearly half (47.3%) of respondents report being unaware of the QDA, suggesting that there may be gaps in public knowledge about key institutions responsible for urban development (Table 4).

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Table 4: Awareness of the Quetta Development Authority (QDA) and its role in urban planning and development in Quetta

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	174	52.7	52.7	52.7
	No	156	47.3	47.3	100.0
	Total	330	100.0	100.0	

Balochistan Development Authority (BDA):

Awareness: Slightly less than half (49.4%) of respondents have heard of the BDA and its responsibilities in Quetta. This finding suggests a similar level of awareness to that of the QDA. Lack of Awareness: Conversely, an almost equal proportion (50.6%) have not heard of the BDA, highlighting the need for increased efforts to inform the public about the roles and responsibilities of such development authorities.

Knowledge of Environmental Protection Agency (EPA):

The survey indicates a significant lack of knowledge among respondents regarding the role and functions of the Environmental Protection Agency (EPA) in Quetta. A majority (51.8%) report being not knowledgeable about the EPA, indicating a potential gap in public awareness and understanding of environmental protection initiatives. Conversely, 39.4% of respondents report moderate knowledge, while only 8.8% claim to be highly knowledgeable about the EPA.

Insights and Implications:

The survey findings underscore the need for significant improvements in local government performance, particularly in the provision of basic services, communication, and citizen engagement. Efforts should be made to increase public awareness of key development authorities like the QDA and BDA, as well as their roles in urban planning and development. There is a pressing need for initiatives to enhance public knowledge and understanding of environmental protection efforts led by agencies like the EPA. Overall, the survey results highlight several areas where interventions and reforms are needed to enhance local governance, promote citizen participation, and improve service delivery in Quetta.

3.5. The principal component

This principal component appears to reflect a combination of factors related to environmental sustainability and infrastructure quality. Observations with higher positive values on PCA1 likely indicate areas with better access to essential amenities such as clean drinking water, sanitation facilities, solid waste management systems, and healthcare facilities. These areas may also have better transportation infrastructure, fewer power outages, higher quality roads, and lower levels of air, water, and noise pollution. Furthermore, they might boast more green spaces and parks, adequate waste management services, and higher satisfaction with public toilets or sanitation facilities. Conversely, observations with lower negative values on PCA1 may represent areas

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where access to these amenities is compromised. These regions might suffer from inadequate access to clean water and sanitation facilities, limited healthcare services, unreliable public transportation, frequent power outages, poor road infrastructure, and high levels of pollution. Additionally, they may lack sufficient green spaces and face challenges with waste management and sanitation facilities maintenance (Figure 3).

This principal component seems to capture additional geographical or spatial characteristics of the areas under study. Positive values on PCA2 might indicate specific geographic features or conditions, such as proximity to natural reserves, bodies of water, or urban centers. Alternatively, they could represent certain demographic or socioeconomic factors unique to particular regions. Negative values on PCA2, conversely, may signify different spatial characteristics or geographical attributes.

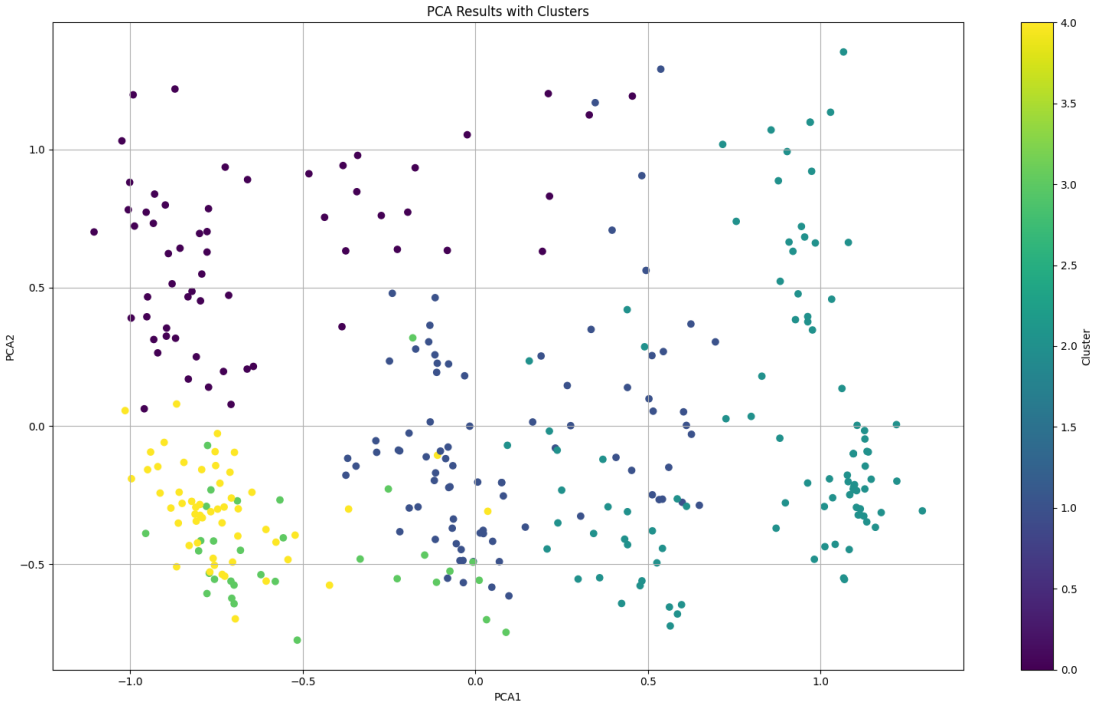

Figure 3: The results of Principal Component Analysis

By analyzing the loadings of the original variables on each principal component, researchers can gain deeper insights into the underlying patterns and relationships within the data. These insights can inform various decisions and policies aimed at promoting environmental sustainability, improving infrastructure quality, and enhancing overall quality of life in the studied areas. Additionally, PCA results can guide targeted interventions and resource allocation strategies to address disparities and challenges identified across different regions.

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3.6. K-means clustering results:

The observed disparities in environmental quality and sustainability likely stem from a combination of socio-economic factors, historical development patterns, and geographical features. Regions with higher income levels and better infrastructure tend to exhibit higher levels of sustainability, while marginalized communities may face disproportionate environmental burdens.

Socio-economic disparities can exacerbate environmental inequalities, with marginalized populations often bearing the brunt of pollution, inadequate infrastructure, and limited access to essential services. Addressing these disparities requires holistic approaches that consider the inter-sectionality of social, economic, and environmental factors.

Access to basic infrastructure and services plays a pivotal role in shaping environmental conditions and overall quality of life. Communities with reliable access to clean water, sanitation facilities, healthcare, and transportation typically experience better environmental outcomes and higher levels of well-being.

Investments in infrastructure and services are essential for promoting sustainable development and enhancing resilience to environmental challenges such as climate change, natural disasters, and pollution. By improving infrastructure, governments and organizations can address immediate needs while laying the foundation for long-term sustainability. The clustering results underscore the importance of targeted policies and interventions to address environmental disparities and promote sustainability.

Policymakers need to adopt a multi-dimensional approach that integrates environmental, social, and economic considerations into decision-making processes. Effective governance structures and regulatory frameworks are crucial for ensuring equitable access to resources, enforcing environmental standards, and fostering community participation in decision-making.

Transparent and accountable governance can enhance trust, facilitate collaboration, and drive positive environmental outcomes. Meaningful engagement with local communities is essential for designing context-specific solutions and empowering residents to actively participate in environmental stewardship (Figure 4).

Community-based initiatives, participatory planning processes, and grassroots organizations can mobilize collective action and drive positive change at the grassroots level. Empowering marginalized communities and amplifying their voices in decision-making processes are central to achieving environmental justice and advancing sustainable development goals.

Building partnerships between government agencies, non-profit organizations, academia, and the private sector can leverage collective expertise and resources to address complex environmental challenges.

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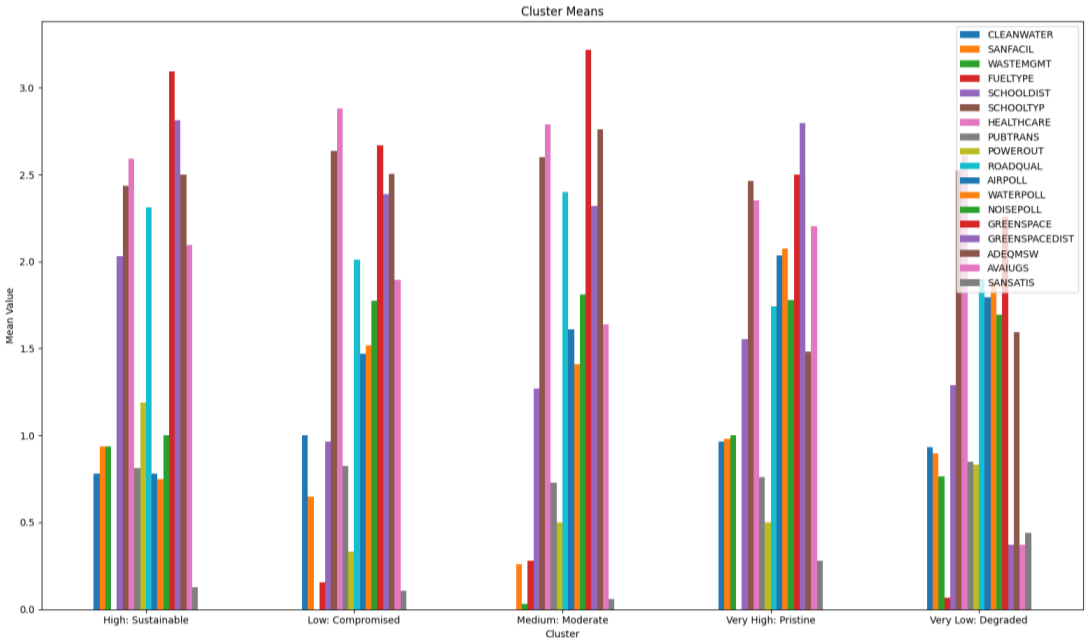

Figure 4: The results of k-means clusters. The results are divided in to six clusters.

3.7. Discussion

This inclusive discussion incorporates the findings of the study on the effectiveness of Environmental Impact Assessments (EIA) in Quetta's urban development, encompassing demographic insights, environmental perceptions, infrastructure quality, waste management systems, awareness of development authorities, and land use and land change analysis. It contextualizes these findings within the broader literature on urban environmental management and sustainability and offers recommendations for policy and practice.

The demographic analysis revealed a diverse participant base, predominantly comprising educated individuals aged between 25-54 years [19, 20]. This demographic profile suggests a potentially influential group regarding urban development and environmental issues. Additionally, the prevalence of larger household sizes reflects traditional family structures prevalent in Quetta, impacting resource use and spatial allocation in urban planning decisions [21].

The study highlighted significant disparities in access to basic amenities such as clean drinking water and sanitation facilities, with over one-third of respondents lacking access. This underscores the urgent need for robust water and sanitation infrastructure in urban planning. Furthermore, perceptions of poor to fair quality of roads and infrastructure among participants, coupled with high levels of reported pollution, point to infrastructural deficits and inadequate urban planning strategies [10]. These findings emphasize the

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importance of comprehensive EIAs prioritizing infrastructure development and pollution mitigation measures.

The majority of communities lack organized waste management systems, with irregular waste management practices reported in a considerable portion of areas [4]. This underscores the urgent need for infrastructure development in waste management. Effective waste management is crucial for reducing pollution and health hazards associated with unmanaged waste. Thus, robust EIAs must ensure waste management considerations are adequately addressed in urban development projects to mitigate environmental impacts. The study findings highlight a significant lack of awareness among the population regarding key development authorities like the Quetta Development Authority (QDA) and the Balochistan Development Authority (BDA), as well as the Environmental Protection Agency (EPA) [12]. This lack of awareness may hinder effective public participation in urban development processes and environmental protection initiatives. Strengthening public awareness and engagement efforts is crucial for enhancing the effectiveness of EIAs and promoting sustainable urban development.

Land Use and Land Change Analysis

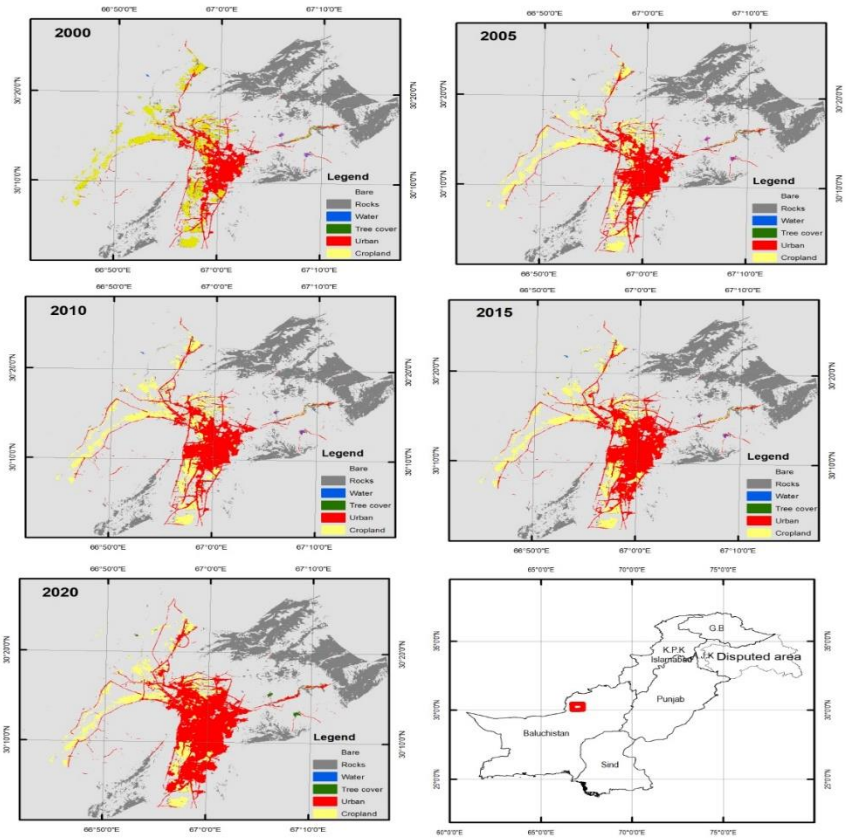

Figure 5: Land Use Land Change trends in the study area from 2000 to 2020.

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The land use and land change analysis conducted in this study reveals significant urban development in Quetta [11]. Mapping and modeling the coordinates of projects subjected to EIAs provide valuable insights into the spatial distribution of development activities and their environmental implications. The expansion of urban areas highlights the need for careful land use planning and effective environmental management practices to mitigate adverse impacts on ecosystems and biodiversity.

Despite the comprehensive nature of the EIAs conducted in Quetta, the study findings suggest limited effectiveness in mitigating the adverse environmental impacts of urban development. The disparities in access to basic amenities, poor infrastructure quality, inadequate waste management systems, and low public awareness of development authorities and environmental agencies indicate significant gaps in EIA implementation and enforcement [3]. While EIAs serve as vital tools for identifying potential environmental risks and guiding sustainable development practices, their effectiveness hinges on rigorous implementation, community engagement, and regulatory enforcement [22].

Based on the study findings and the identified gaps in EIA effectiveness, several recommendations can be proposed to improve urban environmental management and promote sustainable development in Quetta:

- Enhanced EIA Implementation: Strengthen EIA processes to ensure thorough assessment of environmental impacts and effective mitigation measures in all urban development projects [5].
- Community Empowerment: Foster meaningful community engagement in EIA processes to solicit local knowledge, incorporate community perspectives, and promote transparency and accountability in decision-making [23].
- Capacity Building: Invest in capacity building initiatives to enhance the technical expertise of government agencies and stakeholders involved in EIA implementation, monitoring, and enforcement [24].
- Integrated Planning: Integrate infrastructure planning, waste management, and environmental protection considerations into urban development policies and regulations to promote holistic and sustainable urban growth [6].
- Public Awareness Campaigns: Implement targeted public awareness campaigns to educate communities about the importance of EIAs, their role in sustainable development, and avenues for public participation in decision-making processes [25].
- Monitoring and Evaluation: Establish mechanisms for ongoing monitoring and evaluation of urban development projects to assess their environmental impacts, identify emerging challenges, and inform adaptive management strategies [26].

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4. CONCLUSION

The culmination of this research provides significant insights into the effectiveness of Environmental Impact Assessments (EIA) in guiding urban development, with a particular focus on Quetta, Pakistan. Through a multifaceted approach encompassing demographic analysis, environmental perceptions, infrastructure assessment, waste management evaluation, and land use analysis, this study has shed light on the complexities of urban development and the challenges associated with ensuring environmental sustainability. The demographic analysis revealed a diverse population base with varying levels of education, highlighting the need for inclusive and participatory approaches in urban planning processes. Access to basic amenities such as clean drinking water, sanitation facilities, and efficient waste management systems emerged as pressing concerns, underscoring the importance of robust infrastructure development to support urban growth while safeguarding environmental quality.

Furthermore, the study uncovered disparities in public awareness of key development authorities and environmental agencies, signaling gaps in communication and citizen engagement. Effective governance structures and transparent decision-making processes are imperative for fostering public trust and promoting community participation in urban development initiatives. The findings of the land use and land change analysis underscored the rapid pace of urbanization in Quetta, emphasizing the urgency of adopting sustainable land use practices and integrating environmental considerations into urban planning frameworks. While Environmental Impact Assessments serve as critical tools for identifying and mitigating potential environmental risks associated with development projects, their effectiveness in Quetta appears to be constrained by implementation challenges and regulatory gaps.

As we move forward, it is imperative to build upon the findings of this research and continue advancing interdisciplinary collaborations, community engagement initiatives, and policy interventions aimed at promoting sustainable urban development. By leveraging collective expertise and fostering a culture of innovation and inclusivity, we can strive towards creating cities that are not only vibrant and prosperous but also environmentally resilient and socially just.

Through persistent dedication and collaborative action, we can pave the way for a future where urban development harmonizes with nature, enhancing the well-being of present and future generations alike.

References

1) A. B. Hapuarachchi, K. Hughey, and H. Rennie, "Effectiveness of Environmental Impact Assessment (EIA) in addressing development-induced disasters: a comparison of the EIA processes of Sri Lanka and New Zealand," *Natural Hazards* 81: 423-445 (2016).

2) E. Climent-Gil, A. Aledo, and A. Vallejos-Romero, "The social vulnerability approach for social impact assessment," *Environmental Impact Assessment Review* 73: 70-79 (2018).

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 67 Issue 06 | 2024
DOI: 10.5281/zenodo.12295545

3) H. A. Becker and F. Vanclay, *The international handbook of social impact assessment: Conceptual and methodological advances*: Edward Elgar Publishing (2023).

4) B. Dendena and S. Corsi, "The Environmental and Social Impact Assessment: a further step towards an integrated assessment process," *Journal of cleaner production* 108: 965-977 (2015).

5) G. K. Matome, "Stakeholder perspectives and challenges to the institutionalization of strategic environmental assessment in Botswana," *Impact Assessment and Project Appraisal* 42: 173-188 (2024).

6) A. Nita, S. Fineran, and L. Rozylowicz, "Researchers' perspective on the main strengths and weaknesses of Environmental Impact Assessment (EIA) procedures," *Environmental Impact Assessment Review* 92: 106690 (2022).

7) M. Li, W. Du, and S. Tang, "Assessing the impact of environmental regulation and environmental co-governance on pollution transfer: Micro-evidence from China," *Environmental Impact Assessment Review* 86: 106467 (2021).

8) Z. Kabir and I. Khan, "Environmental impact assessment of waste to energy projects in developing countries: General guidelines in the context of Bangladesh," *Sustainable Energy Technologies and Assessments* 37: 100619 (2020).

9) UN, "Food and agriculture organization of the united nations (FAO)," *Yearbook of International Environmental Law* 29: 448-468 (2018).

10) C. Wood, *Environmental impact assessment: a comparative review*: Routledge (2014).

11) Z. Khan, Z. Khan, A. Ahmed, and M. H. Bazai, "Land use/land cover change detection and prediction using the CA-Markov model: A case study of Quetta city, Pakistan," *Journal of Geography and Social Sciences (JGSS)* 2: 164-182 (2020).

12) N. Mushtaq and R. Ali, "Challenges to Elderly People in Quetta City (Balochistan) Pakistan," *Elderly Health Journal* (2020).

13) A. W. Qazi, Z. Saqib, and M. Zaman-ul-Haq, "Diversity and Distribution of Endemic Flora in Pakistan," *Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences* 60: 165-179 (2023).

14) L. De Swardt, "The influence of location on environmental impact assessment: examples from South Africa," North-West University, 2018.

15) J. Petts, *Handbook of Environmental Impact Assessment, Volume 2: Impact and Limitations* 2: John Wiley & Sons (2009).

16) I. Jolliffe, "A 50-year personal journey through time with principal component analysis," *Journal of Multivariate Analysis* 188: 104820 (2022).

17) J. Sreevalsan-Nair, "K-means clustering," in *Encyclopedia of Mathematical Geosciences*: Springer (2021).

18) P. A. Burrough, R. A. McDonnell, and C. D. Lloyd, *Principles of geographical information systems*: Oxford University Press, USA (2015).

19) B. K. Anthonio-Apedzi, "Environmental impact assessment: towards the concept of sustainable development," University of Birmingham, 2020.

20) J. Arts and H. de Vries, "Don’t Shoot the Messenger–Reflections on streamlining and simplification of Environmental Assessment in the Netherlands," *Impact Assessment and Project Appraisal* 41: 238-243 (2023).

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 67 Issue 06 | 2024
DOI: 10.5281/zenodo.12295545

21) D. G. Janka, *Environmental impact assessment in Ethiopia: Laws and practices*: The University of Alabama (2012).

22) D. Naeem, R. Aziz, M. Awais, and S. R. Ahmad, "Assessment of historical and projected changes in extreme temperatures of Balochistan, Pakistan using extreme value theory," *Environmental Monitoring and Assessment* 196: 375 (2024).

23) L. B. Leepile, "A quality review of environmental impact assessment reports for lodge development in Botswana's Okavango Delta," North-West University (South Africa), 2023.

24) Y. Yang, "Reformed environmental impact assessment in China: an evaluation of its effectiveness," (2022).

25) C. Chanchitpricha, K. Swangjang, and A. Morrison-Saunders, "Addressing the spectrum of strategic environmental assessment potential: evolving practice in Thailand and its effectiveness," in *Handbook on Strategic Environmental Assessment*: Edward Elgar Publishing (2021).

26) A. A. Ibrahim, A. Sani, A. M. Gado, M. A. Ibrahim, M. S. Sulaiman, and I. U. Zungum, "Environmental impact assessment in Nigeria-A review," *World Journal of Advanced Research and Reviews* 8: 330-336 (2020).