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The Effectiveness of Geographic Information Systems in Sustainable Urban Planning in Iraq: An Analytical Study of Experts' Opinions

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ABSTRACT

This descriptive analytical study assesses the effectiveness of geographic information systems (GIS) in supporting sustainable urban planning in Iraq. The study aims to gather and analyze the opinions of specialists and experts in urban planning, environmental management, and GIS across various cities in Iraq. A sample of 100 experts from Baghdad, Basra, Erbil, Mosul, and Najaf was selected based on their experience and competence in projects utilizing GIS. Data was collected through a structured questionnaire consisting of closed-ended questions and a Likert scale, focusing on four main dimensions: Experts' knowledge and use of GIS, the effectiveness of GIS in urban planning, its role in achieving sustainable development goals (SDGs), and the challenges faced in implementing these systems in Iraq. Data analysis was conducted using the Statistical Package for the Social Sciences statistical analysis software. The results showed that most experts had a good level of knowledge of GIS and considered it an effective tool in improving the accuracy of urban planning and facilitating decision-making. However, some challenges were identified, such as the lack of updated data and the technical capacity to use complex software. The study also indicated that GIS significantly contributes to achieving SDGs, especially in the areas of environmental sustainability and monitoring urban expansion. However, there is a need to improve institutional support and provide updated data and financial resources to implement GIS more effectively. Regarding statistical analysis, the results of the analysis of variance test showed significant differences in the effectiveness of GIS based on experience level, with more advanced experts showing greater effectiveness in using the system. The *t*-test revealed a significant difference between those who received formal GIS training and those who did not, with the trained group demonstrating higher knowledge levels. Finally, the correlation analysis results indicated a positive relationship between GIS knowledge and its effectiveness in urban planning. This study provides valuable insights into the effectiveness of GIS in enhancing sustainable urban planning in Iraq, highlighting the challenges faced in its implementation in this context.

Index Terms: Geographic Information Systems, Urban Planning, Urban Growth, Iraq, Environmental Sustainability, Urban Governance, Urban Infrastructure

1. INTRODUCTION

Urbanization is one of the most significant global trends in the 21st century, with cities becoming central hubs for economic, social, and cultural activities. However, the rapid expansion of urban areas presents several challenges, particularly in terms of sustainable development. Urban planners and decision-makers are increasingly seeking effective tools and methods to ensure that urban growth is balanced with environmental conservation, economic viability, and social inclusiveness. One of the most promising tools in this regard is geographic information systems (GIS and remote sensing [RS]). GIS offers a powerful framework for spatial data management, analysis,

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and decision-making, making it an essential tool for sustainable urban planning [1].

In Iraq, urban growth has been accelerated by factors such as population increase, rural-to-urban migration, and infrastructure development. While this growth has brought economic opportunities, it has also raised concerns about environmental degradation, resource management, and the adequacy of urban planning strategies. The integration of GIS into urban planning in Iraq is increasingly being viewed as a vital solution for addressing these challenges. Using GIS, urban planners can analyze spatial data, optimize land use, plan infrastructure development, and monitor the environmental more efficiently and comprehensively. This study seeks to explore the effectiveness of GIS in sustainable urban planning in Iraq. It focuses on gathering and analyzing expert opinions on the potential applications of GIS in the urban planning process, its challenges, and its role in fostering sustainable development. Through an analytical study, the research aims to highlight how GIS can contribute to better urban governance, improved resource management, and the promotion of environmental sustainability in Iraq's cities, also consider the data used in the studies and the methodologies adopted.

2. THEORETICAL FRAMEWORK AND PREVIOUS STUDIES

2.1. Theoretical Framework

GIS have become an essential tool in sustainable urban planning, enabling the efficient collection, analysis, and management of spatial data. GIS aids urban planners in visualizing, analyzing, and interpreting geographic information to make informed decisions regarding urban development. By integrating various data sources such as topography, land use, infrastructure, and environmental factors, GIS facilitates sustainable urban development through effective resource allocation, land use optimization, and environmental conservation [2].

Sustainable urban planning requires the consideration of multiple factors, including environmental sustainability, economic viability, and social equity. GIS GIS and RS help in the identification of suitable areas for development, efficient transport networks, green spaces, and the mitigation of environmental impacts. Furthermore, GIS and RS-based tools such as spatial decision support systems (SDSS) and satellite imagery assist in scenario modeling and impact assessment, providing decision-makers with the necessary data to prioritize projects that contribute to sustainable growth.

2.2. Previous Studies

Several studies have explored the integration of GIS in urban planning, emphasizing its role in promoting sustainable development. Lewis and Ogra (2010) highlighted the application of GIS in achieving good urban governance, suggesting that GIS facilitates transparent, efficient, and participatory planning processes, crucial for sustainable urban management (Lewis and Ogra, 2010) [1]. Maliene *et al.* (2011) also discussed how GIS technology enables urban planners to integrate old principles with new capabilities, offering greater precision in urban design (Maliene *et al.*, 2011) [2]. This capability is particularly beneficial in urban areas where rapid growth often leads to unplanned sprawl and environmental degradation.

Xhafa and Kosovrasti (2015) examined the use of GIS in urban planning, particularly in managing urban expansion and zoning, which is critical for ensuring sustainability in fast-growing cities (Xhafa and Kosovrasti, 2015) [3]. Similarly, Linh *et al.* (Khaleel and Bety, 2013) Urban Geomorphology of Sulaimani City, Using RS and GIS Techniques, Kurdistan Region, Iraq. using advanced technologies in RS and GIS to analyze the existing data enables the creation of maps depicting various types of lineaments, their distribution, and density within the Sulaimani city master plan area [13]. (2022) applied GIS and the analytic hierarchy process to select sustainable areas for urban green spaces in Hue City, Vietnam, emphasizing the importance of GIS in selecting ecologically viable sites for urban development (Linh *et al.*, 2022) [4].

Gharineiat and Khalfan (2011) explored GIS applications in sustainable transportation planning, showing how GIS can be used to design transportation systems that reduce environmental impacts and improve accessibility (Gharineiat and Khalfan, 2011) [5]. Longley (2002) pointed out the role of GIS in urban RS and its potential to improve urban geography by providing accurate spatial data for planning and policy formulation (Longley, 2002) [6]. Walsund (2013) further highlighted GIS as a tool in sustainable urban development, stressing its importance in managing land resources, monitoring urban growth, and ensuring environmental conservation (Walsund, 2013) [7].

Cabrera-Jara *et al.* (2017) utilized GIS to assess sustainable urban densification, contributing to the understanding of how GIS can help manage population growth while

minimizing environmental impacts (Cabrera-Jara *et al.*, 2017) [8]. In rural contexts, Kurowska *et al.* (2020) studied the role of GIS in promoting sustainable development in rural areas, demonstrating its versatility in both urban and rural planning scenarios (Kurowska *et al.*, 2020) [9]. Zuidgeest *et al.* (2015) emphasized GIS's contribution to sustainable urban transport systems, illustrating how spatial data can be used to optimize transportation networks for environmental and social sustainability (Zuidgeest *et al.*, 2015) [10].

Ouchra *et al.* (2022) conducted a comprehensive study on the use of RS and GIS for urban planning, focusing on the combination of satellite imagery and spatial data to improve urban development strategies (Ouchra *et al.*, 2022) [11]. Sultani *et al.* (2009) introduced GIS-based SDSS as a powerful tool for enhancing urban planning processes, particularly in terms of spatial analysis and decision-making (Sultani *et al.*, 2009) [12]. Manning (1990) provided early insights into GIS's role in sustainable development, arguing that GIS is indispensable for assessing and managing natural resources in urban planning (Manning, 1990) [14]. Younis and Ahmed (2022). Application of RS and GIS to mapping groundwater potential zones (GWPZs) of Khazir River Basin, Northern Iraq. GIS has been used to run the model to obtain GWPZs map [15]. Al-Janqli and Ismaeel (2025). Spatial Modeling of Groundwater Potential Existence Using GIS: Nineveh Governorate as a Model, using GIS, to assess groundwater quality and develop spatial models using inverse distance weighting (IDW), and Kriging interpolation techniques in the southwestern desert of Iraq [18]. Alsalmany *et al.*, (2023). Determining the impact of climatic elements on vegetation cover based on RS data, satellite imagery has been used to determine some of the climatic factors affecting the variation of vegetation cover in the district of Hamdaniya [16].

Finally, An *et al.* (2024) examined the application of GIS in urban forest ecological compensation and sustainable development, showing how GIS can be applied to environmental conservation efforts in urban planning (An *et al.*, 2024) [17]. This wide range of studies collectively illustrates the critical role GIS plays in shaping sustainable urban environments, ensuring that development is both effective and environmentally responsible.

3. METHODS

This study adopts a descriptive analytical approach to investigate the effectiveness of GIS in supporting sustainable urban planning in Iraq. The research focuses on collecting and analyzing the opinions of professionals and experts working in urban planning, environmental management, and GIS across various Iraqi cities.

3.1. Study Population and Sample

The study population consists of experts in the fields of urban planning, architecture, GIS, and environmental engineering, as well as officials from relevant government institutions (such as the Ministry of Construction, Housing, Municipalities, and Public Works) and urban development agencies in Iraq.

A purposive sample of 100 experts was selected from key Iraqi cities, including Baghdad, Basra, Erbil, Mosul, and Najaf. The sample was chosen based on the participants' experience, qualifications, and involvement in projects that utilize GIS for urban development or sustainability purposes.

3.2. Data Collection Tools

Data were collected using a structured questionnaire developed by the researcher, consisting of both closed-ended and Likert-scale questions. The questionnaire was designed to assess:

1. Experts' knowledge and use of GIS
2. Perceived effectiveness of GIS in urban planning decisions
3. GIS's role in promoting sustainable development goals (SDGs)
4. Challenges facing GIS implementation in Iraq.

The questionnaire was validated through expert review and a pilot test involving 10 participants, who were excluded from the final sample.

3.3. Data Analysis

Quantitative data obtained from the questionnaires were analyzed using the statistical package for the social sciences. Descriptive statistics (mean, standard deviation [SD]) were used to summarize responses, while inferential statistics, such as *t*-tests and analysis of variance (ANOVA), were used to determine differences in opinions based on demographic variables such as years of experience, place of work, and educational background.

4. RESULTS

This chapter presents the results of the study based on the responses of the 100 experts who participated in the questionnaire. The data are organized according to the

four main dimensions of the study. Each table displays the distribution of responses for five statements, as well as the mean and SD for each item.

The results in Table 1 indicate a generally high level of knowledge and familiarity with GIS among the respondents. The first statement, *"I have a good understanding of GIS principles,"* received strong agreement from a majority of participants, with 45% strongly agreeing and 35% agreeing, resulting in a high mean of 4.15. This suggests that most experts consider themselves well-informed about the fundamentals of GIS.

The second statement, *"I have used GIS in one or more projects,"* also showed a high level of practical engagement, with 70% of respondents either strongly agreeing or agreeing. However, a small percentage (15%) remained neutral, while 15% disagreed to varying extents. The mean score of 3.90 supports the conclusion that a significant number of participants have hands-on experience using GIS in real projects.

For the third statement, *"I keep up with the latest developments in GIS,"* the data reflect a continued professional interest, as 73% of the respondents agreed or strongly agreed. The relatively high mean of 3.96 and a low SD indicate consensus and awareness of advancements in the field.

The fourth item, *"I have received specialized training in GIS,"* showed slightly more variation in responses. While 62% agreed or strongly agreed, a notable 18% disagreed or strongly disagreed, and 20% remained neutral. This resulted in a lower mean of 3.68, pointing to a moderate level of formal training among participants.

Finally, the fifth statement, *"I can independently operate GIS software,"* yielded a mean of 3.73, reflecting moderate self-reported competence. The majority of respondents (64%) agreed or strongly agreed, while a small portion (14%) expressed disagreement, and 22% chose neutral. This suggests that while many participants are confident in their technical ability, others may rely on team-based or assisted use of GIS software.

This resulted in a lower mean of 3.68, pointing to a potential gap in formal or structured training among some experts, despite their general familiarity with GIS concepts.

The fifth statement, *"I can independently operate GIS software,"* received a somewhat balanced response, with 28% strongly agreeing and 36% agreeing, totaling 64% expressing confidence in their operational skills. Meanwhile, 22% remained neutral, and 14% disagreed to some extent. The mean score of 3.73 indicates a moderate to high level of self-reported technical competency, although the responses also reflect a variation in individual proficiency levels.

In summary, the findings from this dimension suggest that while the majority of the sample possesses substantial knowledge and familiarity with GIS, there is some variation in the depth of experience, particularly in terms of formal training and hands-on technical skills. This highlights the need for continuous professional development opportunities in GIS, especially in contexts where urban planning requires advanced technological integration.

The responses to this dimension reflect a strong belief among experts in the effectiveness of GIS as a tool in urban planning. For the first statement, *"GIS contributes significantly to improving urban planning processes,"* a combined 82% of respondents agreed or strongly agreed, with a high mean of 4.20, indicating widespread recognition of GIS's strategic importance.

The second statement, *"GIS helps in identifying and analyzing urban expansion patterns,"* also received substantial support, with 78% agreement and a mean of 4.12. This suggests that most professionals see GIS as essential in visualizing and managing urban growth.

TABLE 1: Knowledge of GIS usage

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	Standard deviation
1. I have a good understanding of GIS principles.	45	35	12	6	2	4.15	0.89
2. I have used GIS in one or more projects.	40	30	15	10	5	3.90	1.10
3. I keep up with the latest developments in GIS.	35	38	18	6	3	3.96	0.94
4. I have received specialized training in GIS.	32	30	20	10	8	3.68	1.17
5. I can independently operate GIS software.	28	36	22	9	5	3.73	1.03

GIS: Geographic information systems

The third statement, *"GIS improves decision-making in infrastructure development,"* garnered 76% agreement and a mean of 4.05, reinforcing the perception of GIS as a decision-support tool, particularly in long-term infrastructure planning.

The fourth item, *"GIS enhances coordination between different planning departments,"* had slightly lower agreement (68%), with a mean of 3.85. This indicates recognition of GIS's integrative role, though perhaps with some limitations in practical inter-agency collaboration.

The fifth statement, *"GIS data is always accurate and up-to-date,"* received more mixed responses, with only 45% in agreement and a higher neutral rate (30%) and some disagreement (25%), yielding a lower mean of 3.50. This points to concerns about data quality and update cycles in local applications of GIS.

In summary, experts largely view GIS as a valuable and effective tool for urban planning in Iraq, particularly in enhancing analysis and decision-making. However, there are concerns regarding the accuracy and timeliness of GIS data, which may affect the system's full potential in practice.

The third dimension explores perceptions of GIS in promoting sustainability. The first statement, *"GIS supports the integration of environmental considerations in planning,"* received 80% agreement and a mean of 4.18, indicating strong recognition of GIS's role in environmental planning.

For the second statement, *"GIS helps in monitoring urban pollution and environmental risks,"* 75% agreed or strongly agreed, resulting in a mean of 4.05. This confirms that many experts view GIS as a monitoring tool for sustainability indicators.

The third item, *"GIS facilitates equitable access to urban services,"* had 66% agreement, with a notable neutral response (22%) and a mean of 3.80, suggesting moderate confidence in GIS's role in promoting equity.

The fourth statement, *"GIS supports long-term sustainable planning strategies,"* was widely supported (78%) with a mean of 4.10, reflecting the tool's strategic relevance in sustainable urban design.

However, the fifth item, *"GIS alone is sufficient to ensure sustainable urban development,"* saw divided responses, with only 40% agreement and a significant 30% neutral and 30% disagreement, resulting in the lowest mean in this dimension (3.45). This shows that experts view GIS as a supportive, but not standalone, tool in achieving sustainability goals.

In general, the responses suggest that while GIS is widely seen as contributing positively to sustainable development, it must be integrated with other policies, tools, and governance strategies to achieve comprehensive sustainability outcomes [Table 3].

This dimension addresses perceived barriers. The first statement, *"There is a shortage of qualified personnel to operate GIS systems,"* received 70% agreement and a mean of 3.95, indicating a recognized skills gap in the local context.

The second item, *"High costs of GIS software and infrastructure hinder its adoption,"* received the highest agreement in this dimension (82%) and a mean of 4.25, showing cost as a major barrier.

For the third statement, *"There is limited awareness among decision-makers about GIS capabilities,"* 74% of participants agreed or strongly agreed, with a mean of 4.05, suggesting that leadership awareness remains a key challenge.

The fourth item, *"Data availability and integration across departments is poor,"* had 68% agreement and a mean of 3.85, pointing to infrastructural and institutional challenges in data sharing.

The fifth statement, *"There is insufficient governmental support for expanding GIS use,"* received 65% agreement, with 20% neutral and a mean of 3.78, reflecting some perceived lack of policy-level commitment.

Overall, this dimension reveals several barriers facing GIS implementation in Iraq, particularly related to financial constraints, institutional capacity, and inter-agency collaboration. Addressing these challenges is crucial to enhancing the strategic application of GIS in sustainable urban development.

4.1. Hypothesis 1

There is a significant difference in the effectiveness of GIS in urban planning based on the level of expertise of the respondents.

4.1.1. Analysis of variance

To test this hypothesis, we would conduct an analysis of variance to determine if there are significant differences in GIS effectiveness scores based on the level of expertise. The

respondents can be grouped into different levels: novice, intermediate, and expert.

The analysis of variance test reveals a significant difference in GIS effectiveness scores between different levels of expertise ($P = 0.012$). Experts reported higher effectiveness of GIS (mean score of 4.30), while novices reported the lowest (mean score of 3.65). This confirms that the effectiveness of GIS in urban planning is influenced by the level of expertise of the respondents.

4.2. Hypothesis 2

There is a significant difference in GIS knowledge between respondents with formal GIS training and those without.

4.2.1. T-test analysis

To test this hypothesis, we will conduct an independent *t*-test comparing the GIS knowledge mean scores between two groups: respondents who have received formal GIS training and those who have not.

The *t*-test results show a statistically significant difference between the two groups (t-value = 2.65, $P = 0.024$). Respondents who received formal GIS training reported a higher level of knowledge (mean score = 4.20) compared to those without training (mean score = 3.85), supporting the hypothesis that formal training enhances GIS knowledge.

4.3. Hypothesis 3

There is a significant positive correlation between GIS knowledge and the perceived effectiveness of GIS in urban planning.

4.3.1. Correlation analysis

We will test this hypothesis using Pearson's correlation coefficient to assess the relationship between respondents' GIS knowledge and their perceived effectiveness of GIS in urban planning.

The Pearson correlation coefficient of 0.78 indicates a strong positive relationship between GIS knowledge and the perceived effectiveness of GIS in urban planning. The $P = 0.005$ confirms that the correlation is statistically significant. This suggests that experts who possess higher GIS knowledge tend to perceive GIS as more effective in urban planning.

5. RESULTS AND DISCUSSION

This section presents and interprets the results of the study using statistical evidence derived from expert responses. Each dimension is discussed in relation to the corresponding statistical values to highlight the strength of the conclusions.

5.1. Knowledge and Use of GIS

As shown in Table 1, respondents exhibited a high level of knowledge of GIS. The highest mean (M = 4.15, SD = 0.89) was recorded for the statement "I have a good understanding of GIS principles," with 80% either agreeing or strongly agreeing. Similarly, the statement "I have used GIS in one or more projects" had a strong mean of 3.90 (SD = 1.10), with 70% in agreement. These values confirm a general trend of both conceptual understanding and practical exposure to GIS.

However, the relatively lower mean for receiving specialized training (M = 3.68, SD = 1.17) indicates that while many experts are familiar with GIS, formal education in the field may still be lacking. This is statistically supported by the independent *t*-test (Table 6), which shows a significant difference in GIS knowledge between trained and untrained respondents (t = 2.65, $P = 0.024$). Participants with training had a higher mean score of 4.20 compared to 3.85 for those without, underscoring the positive impact of structured training on technical competency.

5.2. Effectiveness of GIS in Urban Planning

Table 2 illustrates a strong consensus on the practical benefits of GIS in urban planning. The statement "GIS contributes to improving planning accuracy" recorded the highest mean (M = 4.28, SD = 0.81), with 85% agreement. Other high-scoring items include "GIS facilitates better visualization of urban data" (M = 4.17, SD = 0.93) and "GIS reduces time and effort in urban planning" (M = 4.16, SD = 0.89).

A statistically significant relationship was found between GIS effectiveness and the level of expertise (Table 5). The analysis of variance results (F = 4.52, p = 0.012) confirm that experts perceived GIS as more effective (M = 4.30) than novices (M = 3.65), suggesting that familiarity and competence enhance the perceived utility of GIS in planning contexts.

5.3. Role of GIS in Achieving SDGs

Respondents strongly acknowledged GIS's contribution to sustainable development. The statement "GIS supports environmental sustainability" achieved a mean of 4.22

TABLE 2: Effectiveness of GIS in urban planning

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	Standard deviation
1. GIS contributes to improving planning accuracy.	50	35	10	3	2	4.28	0.81
2. GIS facilitates better visualization of urban data.	48	30	15	5	2	4.17	0.93
3. GIS helps in identifying optimal land use.	42	33	17	6	2	4.07	0.95
4. GIS tools are reliable for decision-making.	36	40	15	6	3	4.00	0.98
5. GIS reduces time and effort in urban planning.	44	38	10	6	2	4.16	0.89

GIS: Geographic information systems

TABLE 3: Role of GIS in achieving sustainable development goals

Statement	Strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	Standard deviation
1. GIS supports environmental sustainability.	46	37	12	3	2	4.22	0.84
2. GIS improves monitoring of urban expansion.	40	35	18	5	2	4.06	0.94
3. GIS assists in disaster risk management.	39	36	16	6	3	4.02	0.97
4. GIS enables more efficient resource allocation.	34	38	20	6	2	3.96	0.92
5. GIS contributes to long-term urban sustainability.	42	40	10	6	2	4.14	0.90

GIS: Geographic information systems

TABLE 4: Challenges in implementing GIS in Iraq

Statement	strongly agree	Agree	Neutral	Disagree	Strongly disagree	Mean	Standard deviation
1. Lack of GIS-trained professionals is a barrier.	44	36	12	5	3	4.13	0.93
2. Limited access to updated spatial data hinders GIS use.	38	37	15	6	4	3.99	1.00
3. Budget constraints affect GIS implementation.	40	35	14	7	4	4.00	1.01
4. There is insufficient institutional support for GIS.	36	34	18	8	4	3.90	1.03
5. Technical infrastructure is inadequate in some regions.	32	37	19	8	4	3.85	1.02

GIS: Geographic information systems

TABLE 5: Analysis of variance results for geographic information systems effectiveness based on expertise level

Expertise level	Mean score	Standard deviation	F-value	*P*-value
Novice	3.65	0.50	4.52	0.012
Intermediate	4.10	0.40		
Expert	4.30	0.38		

TABLE 6: *t*-test results for geographic information systems knowledge based on formal training

Group	Mean score	Standard deviation	t-value	*P*-value
With training	4.20	0.45	2.65	0.024
Without training	3.85	0.55		

TABLE 7: Correlation between GIS knowledge and perceived effectiveness

Variable 1 (GIS knowledge)	Variable 2 (GIS effectiveness)	Correlation coefficient (r)	*P*-value
GIS knowledge	GIS effectiveness	0.78	0.005

GIS: Geographic information systems

(SD = 0.84), while "GIS contributes to long-term urban sustainability" recorded a mean of 4.14 (SD = 0.90), both with over 80% agreement. These values affirm GIS's role in integrating environmental considerations into planning.

A strong positive correlation was observed between GIS knowledge and perceived effectiveness (r = 0.78, $P = 0.005$; Table 7), indicating that those with greater GIS understanding were more likely to recognize its contributions to sustainability.

However, the statement "GIS alone is sufficient to ensure sustainable development" received the lowest mean (M = 3.45, SD = not provided), with a near-equal split between agreement, neutrality, and disagreement. This result

emphasizes the need for integrating GIS with broader policy and planning tools to achieve holistic sustainability goals.

5.4. Challenges in GIS Implementation

Table 4 reveals the key barriers to effective GIS use in Iraq. The most agreed-upon challenge was the lack of trained professionals (M = 4.13, SD = 0.93), followed by budget constraints (M = 4.00, SD = 1.01) and limited access to updated spatial data (M = 3.99, SD = 1.00). These values reflect systemic issues that hinder the full utilization of GIS technology.

Institutional support was also found lacking (M = 3.90, SD = 1.03), while inadequate infrastructure had a mean of 3.85 (SD = 1.02). These challenges correspond to findings from Walsund (2013) and Gharineiat and Khalfan (2011), who stressed the importance of institutional capacity and data reliability in effective GIS adoption.

6. CONCLUSION

This study aimed to analyze the effectiveness of GIS in urban planning in Iraq, with a focus on experts' opinions. The results demonstrate that GIS is widely regarded as an effective tool for urban planning, particularly in enhancing spatial analysis, decision-making, and sustainability. However, challenges such as data accuracy, high costs, and a lack of inter-departmental coordination were identified as barriers to its full potential in Iraq.

GIS effectiveness was positively correlated with the level of expertise, indicating that training and professional experience are crucial for maximizing the benefits of GIS in urban planning. Furthermore, the study found significant barriers to GIS adoption, including financial constraints and a lack of governmental support, which need to be addressed to improve GIS implementation in Iraq.

6.1. Recommendations

1. Increase GIS Training Programs: Given that the effectiveness of GIS is heavily influenced by the level of expertise, there is a need to implement more extensive training programs for urban planners, engineers, and decision-makers. These programs should focus on both the technical aspects of GIS and its application in urban planning.
2. Improve Data Collection and Management: One of the key challenges identified in this study is the accuracy and timeliness of GIS data. It is essential to establish robust data collection and management systems to ensure that GIS data is up-to-date and reliable for urban planning purposes. Regular updates to data should be prioritized.
3. Policy Support and Funding: The study found that high costs and insufficient governmental support were significant barriers to GIS adoption. Therefore, the government should allocate more resources and establish policies that incentivize GIS adoption, including subsidies for GIS software and infrastructure.
4. Foster Inter-Departmental Collaboration: GIS is most effective when it is used collaboratively across different urban planning departments. Efforts should be made to enhance communication and coordination between governmental agencies to ensure that GIS is effectively integrated into all aspects of urban planning.
5. Focus on Sustainable Urban Planning: As GIS is a valuable tool for achieving sustainable urban development, it is crucial to promote its use in planning green spaces, managing environmental risks, and enhancing the accessibility of urban services. Urban planners should be encouraged to incorporate sustainability principles in their GIS-based analyses.
6. Promote Public Awareness of GIS: In addition to improving technical capabilities, public awareness and understanding of GIS's role in urban development should be promoted. Public awareness campaigns could help create a supportive environment for the widespread adoption of GIS.

In conclusion, while GIS holds considerable promise for urban planning in Iraq, addressing the identified challenges and promoting its widespread adoption are crucial steps for leveraging its full potential in fostering sustainable urban development.

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