Journal of Al-Farahidi's Arts, No Conference (10 th)N(I)120-129
Doi: https://doi.org/10.25130/jfa.conf.10.1.6

Proceedings of the (10) Conference وقائع المؤتمر العلمي العاشر

P-ISSN : 2074-9554 | E-ISSN: 2663-811
Journal of Al-Farahidi's Arts
available online at : fja.tu.edu.iq/index.php/fja

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The Reality of Artificial Intelligence Applications in Applied Geography in Libya

Keywords:
Artificial Intelligence ,
Applied Geography, Geographic Information Systems (GIS),

Article history:

Received	7/9/2025
Received in revised form	27/9/2025
Accepted	19/10/2025
Available online	9/12/2025

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A B S T R A C T

This study seeks to explore the current state of artificial intelligence (AI) applications in the field of applied geography in Libya, within the context of the developmental and spatial challenges facing the country. It emerges from the pressing need to adopt modern technological tools capable of supporting decision-makers and directing spatial development toward greater efficiency and sustainability. The significance of the research lies in its treatment of an advanced intersection between geography—as an analytical and spatial science—and artificial intelligence—as a revolutionary technology that offers unprecedented capabilities in processing spatial data, monitoring geographic phenomena, and providing accurate predictive models across various domains such as urban planning, resource management, and environmental change tracking.

The study adopts a descriptive-analytical methodology, based on a review of relevant literature and expert interviews with professionals in artificial intelligence and geographic information systems. This approach aims to understand the depth of current AI applications and assess the readiness of Libyan institutions to adopt such advanced technologies.

The findings reveal that the use of AI in applied geography in Libya remains limited, mostly confined to individual research initiatives or academic projects, and has yet to be integrated into sustainable institutional frameworks or national policy-making structures.

واقع استخدامات الذكاء الاصطناعي في الجغرافيا التطبيقية في ليبيا

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المستخلص:

تسعى هذه الدراسة إلى استكشاف واقع استخدامات الذكاء الاصطناعي في مجال الجغرافيا التطبيقية في ليبيا، في ظل التحديات التنموية والمكانية التي تواجهها البلاد، وضمن سياق الحاجة الملحة لتبني أدوات تقنية حديثة قادرة على دعم صناع القرار وتوجيه التنمية المكانية نحو مزيد من الكفاءة والاستدامة، وتنبع أهمية البحث من كونه يتناول تقاطعاً معرفياً متقدماً بين الجغرافيا كعلم تحليلي مجالي، والذكاء الاصطناعي كتقنية ثورية تتيح إمكانيات غير مسبوقة في معالجة البيانات المكانية، ورصد الظواهر الجغرافية، وتقديم نماذج تنبؤية دقيقة في مجالات متعددة، مثل التخطيط الحضري، إدارة الموارد، وتتبع التغيرات البيئية.

وقد اعتمدت الدراسة منهجاً وصفياً تحليلياً ارتكز على مراجعة الأدبيات المتخصصة، إلى جانب إجراء مقابلات مع عدد من الخبراء والمهنيين في مجالات الذكاء الاصطناعي ونظم المعلومات الجغرافية، بهدف فهم عمق الاستخدامات الحالية وتقييم جاهزية المؤسسات الليبية لاعتماد هذه التقنيات المتقدمة.

وأظهرت نتائج الدراسة أن توظيف الذكاء الاصطناعي في الجغرافيا التطبيقية الليبية لا يزال محدوداً ويقتصر في معظمه على بعض المبادرات البحثية الفردية أو المشاريع الأكاديمية، دون أن يرقى بعد إلى مستوى السياسات أو الأطر المؤسسية المستدامة

الكلمات المفتاحية : الذكاء الاصطناعي، الجغرافيا التطبيقية، نظم المعلومات الجغرافية، التنمية المستدامة

1. Introduction

The world is witnessing rapid technological transformations that have led to the emergence of advanced technologies such as Artificial Intelligence (AI), which has profoundly impacted various sciences, including applied geography. Libya faces complex developmental and spatial challenges that require smart and integrated solutions to support sustainable development. AI represents a promising opportunity to enhance the efficiency of spatial data management and geographic phenomena analysis, in addition to supporting urban and environmental planning. This study aims to shed light on the reality of AI usage in applied geography in Libya and assess the readiness level of institutions for effective adoption of this technology.

2. Problem Statement

Libya suffers from significant challenges in spatial development due to unregulated population growth, lack of reliable spatial data, and deteriorating technical infrastructure. In this context, the core question arises:
"What is the reality of Artificial Intelligence usage in applied geography in Libya, and to what extent does this technology contribute to supporting planning and sustainable development?"
This question branches into the following sub-questions:

a) To what extent is AI used in geographic research and planning institutions?
b) What are the obstacles facing the adoption of these technologies in the Libyan context?
c) How can AI integration in applied geography be enhanced to achieve better developmental outcomes?

3. Objectives

The study aims to:

a) Assess the current applications of AI in applied geography in Libya.
b) Identify the technical and institutional capacities available for adopting AI technologies.
c) Analyze the challenges and opportunities associated with the practical use of AI.
d) Provide practical recommendations to enhance AI integration in spatial development.

4. Significance of the Study

This study is important because it:

a) Bridges the knowledge gap regarding AI usage in applied geography within Libya.
b) Provides a clear perspective for decision-makers on the technical and human readiness for AI adoption.

c) Raises awareness of the role of modern technology in addressing developmental and spatial challenges.
d) Contributes to laying developmental foundations for integrating modern technologies into Libyan geographic and planning institutions.

5. Methodology:

This study adopts a descriptive-analytical approach that includes reviewing literature and previous studies on AI in applied geography. It also conducts interviews with experts and specialists in AI and Geographic Information Systems (GIS) in Libya. Moreover, it analyzes the reality of Libyan research and planning institutions concerning AI technology adoption.

6. Theoretical Framework:

6.1 Concept of Artificial Intelligence (AI):

Artificial Intelligence is defined as a branch of computer science aimed at developing systems capable of simulating human cognitive abilities such as learning, understanding, and decision-making (Russell & Norvig, 2021). It includes technologies such as Machine Learning and Deep Learning, which enable the analysis of complex, multi-dimensional data.

a) Applied example: Li et al. (2018) used deep neural networks to analyze satellite images for accurately monitoring vegetation changes, improving agricultural area management.

6.2 AI and Geographic Information Systems (GIS):

The integration of AI with GIS is a major advancement in spatial data processing.

a) Supporting study: Goodchild (2018) noted that AI expands GIS capabilities through self-learning of patterns and improving modeling accuracy.
b) Applied example: Machine learning techniques were used to analyze traffic data in Chicago, improving traffic management and reducing congestion by 15% (Wang et al., 2020).

6.3 Sustainable Urban Development and Its Dimensions:

Sustainable urban development balances economic, social, and environmental dimensions while ensuring resource sustainability (UN-Habitat, 2020).

a) Applied study: Angelidou et al. (2017) used AI models to simulate urban planning policies' impacts on carbon emissions in Barcelona, helping formulate plans that reduced emissions by 25% over a decade.

6.4 AI in Natural Resource Management:

AI can improve resource management through analyzing complex environmental data:

a) Study: Krause et al. (2020) applied machine learning algorithms to predict water requirements for smart agriculture in Germany, reducing water consumption by 20%.
b) Libyan example: Despite limited studies, initial research includes using remote sensing data to analyze vegetation changes in the Green Mountain region (Alhussein et al., 2021).

6.5 AI in Urban Transport Planning:

AI is employed to optimize transportation networks:

a) Study: Zhou et al. (2021) highlighted AI-based smart transport systems managing traffic in Shanghai, reducing commute times by 18%.
b) Libyan example: Research initiatives are underway to implement intelligent traffic monitoring systems in Benghazi using smart cameras to analyze vehicle flow (Al-Badri & Miftah, 2022), though comprehensive development is still needed.

6.6 Supporting Theories:

a) Urban Smart Systems Theory: Batty (2013) described the city as a complex system that AI can optimize by modeling urban interactions.
b) Digital Transformation in Governance: Nam & Pardo (2011) emphasized the importance of technology in enhancing citizen participation in decision-making.
c) Open Innovation Theory: Chesbrough (2003) highlighted the necessity of collaboration among institutions to adopt advanced technologies like AI.

6.7 International Supporting Experiences:

a) Singapore: The "Smart Nation" initiative uses AI to improve urban services such as air quality monitoring, energy management, and traffic control (Smart Nation Singapore, 2020).
b) Barcelona: Smart waste bins equipped with AI sensors schedule waste collection efficiently, reducing costs (Barcelona Smart City Report, 2021).
c) The Netherlands**:** AI is used for flood prediction and improved water and transport management (Kroese et al., 2019).
d) South Korea: Smart cities use AI for urban planning, citizen engagement, and data analysis (Korea Smart City Report, 2022).

7. Challenges and Opportunities in Using AI in Applied Geography:

7.1 Challenges:

Despite the enormous potential of AI in enhancing urban and geographic planning, its adoption faces fundamental challenges in developing countries like Libya:

a) Lack of technical infrastructure: Many Libyan institutions suffer from weak digital networks, absence of data centers, and lack of modern devices necessary to efficiently operate AI technologies (UN-Habitat, 2020).

b) Weak human capacities and training: The scarcity of qualified technical staff in AI and GIS fields forms a major obstacle, leading to limited reliance on these technologies despite their availability (Krause et al., 2020).
c) Lack of reliable spatial data: AI depends on vast, accurate data, which is insufficient in Libya due to weak monitoring systems and irregular updates of geographic databases (Alhussein et al., 2021).
d) Incomplete legal and regulatory frameworks: The absence of clear legislation governing AI use, data privacy, and protection hinders responsible and safe application (Nam & Pardo, 2011).
e) Institutional resistance to change: Some government bodies are characterized by administrative inertia and fear of digital transformation, delaying AI integration into official policies and plans (Angelidou et al., 2017).

7.2 Opportunities:

Conversely, promising opportunities exist to support expanding AI use in applied geography and urban development in Libya:

a) Increasing international and local digital transformation interest: UN programs and international organizations provide technical and financial support for projects aiming to build digital capacities in developing countries (UN-Habitat, 2020).
b) Availability of open-source technologies: Free and open-source AI and GIS tools and applications offer opportunities for learning and development without heavy investments (Goodchild, 2018).
c) Growing base of tech-savvy youth: A young generation interested and qualified in computing and AI fields forms a solid base for specialized teams within Libyan institutions (Al-Badri & Miftah, 2022).
d) Potential to improve urban planning quality: Using AI to analyze population distribution, resource management, and environmental monitoring can enable more accurate and effective planning, reducing the impacts of random urban growth and environmental degradation (Zhou et al., 2021).
e) Possibility of multi-sector partnerships: Collaboration among public and private sectors, universities, and civil society can accelerate AI adoption and ensure it serves developmental goals (Chesbrough, 2003).

In brief, addressing technical and regulatory challenges and leveraging existing opportunities in human capacities and technology constitute the most effective pathway to integrating AI in applied geography in Libya to achieve sustainable urban development that meets present needs and preserves future generations' rights.

8. Practical Framework:

Analysis of Survey Results on the Adoption of Artificial Intelligence (AI) Technologies in Libyan Institutions Involved in Applied Geography.

8.1. Nature of Represented Institutions in the Survey:

The data reveals notable diversity among participating entities, with equal representation from government institutions, research centers, and universities (33.3%

each). This balanced participation reflects the involvement of decision-makers, academic practitioners, and researchers alike. The inclusion of technology firms, civil society organizations, and independent professionals—though to a lesser extent—further enhances the comprehensiveness of the national landscape. This institutional diversity lends credibility to the results and indicates an awareness among stakeholders of the importance of AI, albeit with varying capabilities and levels of adoption.

8.2. Geographic Distribution of Respondents:

The findings show that the majority of participants are from the Benghazi region (94.4%), possibly reflecting a concentration of research and technical activity, or a higher response rate in that region compared to others. The weak representation from the Sabha and Sirte regions underscores the need to enhance decentralization in technological initiatives and capacity-building in inland areas.

8.3. Professional Composition of Respondents:

University faculty members dominate the sample at 66.7%, followed by academic researchers and urban planners. This indicates a strong academic presence and the involvement of disciplines closely related to urban planning and Geographic Information Systems (GIS).This composition reflects a knowledge-based orientation in evaluating AI from a scientific and institutional perspective, rather than solely from a technical or operational angle.

8.4. Extent of AI Usage:

Despite broad recognition of the importance of AI, 44.4% of respondents reported that their institutions do not currently utilize AI technologies, while 33.3% are in the experimentation or training phase. Only 22.2% confirmed actual implementation. These figures suggest that Libya is still in an exploratory phase regarding AI, requiring supportive policies to accelerate the transition toward effective institutional application.

8.5. Current Fields of AI Application:

The most prominent areas of AI usage identified are:

a) GIS (Geographic Information Systems): 66.7%
b) Urban Planning and Development: 55.6%
c) Natural Resource Management: 38.9%
d) Satellite Imagery and Remote Sensing Analysis: 33.3%
e) Traffic Monitoring and Intelligent Transport Systems: 33.3%

These results highlight the integration of AI into applied geographical activities and pave the way for synergy between technical tools and spatial analysis to support sustainable urban planning and decision-making.

8.6. Institutional Expertise in AI:

The majority (61.1%) rated their institutions' expertise in AI as low, while 38.9% classified it as moderate. None rated their expertise as high. This indicates a significant barrier to the widespread implementation of AI technologies and calls for intensive and continuous training programs, especially in light of the rapid evolution of AI.

8.7. Challenges Facing AI Adoption:

Table (1) presents the most prominent challenges as identified by the participants involved in the field study.

Table1: *most prominent challenges*

Challenge	Percentage
Lack of qualified technical personnel	72.2%
Inadequate technical infrastructure	66.7%
Insufficient funding and financial support	55.6%
Institutional resistance to change	50%
Weak spatial data and reliability	44.4%
Absence of legal and regulatory frameworks	38.9%

Source: *Field Study 2025*

These numbers emphasize that human resource limitations and weak infrastructure are the most significant barriers to digital transformation, followed by funding gaps and a lack of supportive legislation—highlighting the absence of a clear national strategy in this domain.

8.8. Opportunities for Supporting AI:

Table (2) illustrates the most prominent opportunities according to the opinions of the participants included in the field study.

Table2: *most Opportunities for Supporting AI*

Opportunity	Percentage
Increasing institutional awareness and training	83.3%
Developing technical infrastructure	77.8%
Collaboration with universities and research centers	72.2%
Provision of open-source and low-cost tools	66.7%
Clear legislation and regulatory frameworks	55.6%

Source: *Field Study 2025*

These results demonstrate a widespread belief that training and capacity-building are the keys to advancing AI adoption, alongside infrastructure development and academic partnerships.

8.9. Perceived Importance of AI in Urban Development:

A vast majority (77.8%) considered AI to be very important for achieving sustainable urban development, while 22.2% viewed it as somewhat important. Notably, no participants expressed doubt about its relevance or importance.
This consensus reflects a strong mental readiness to adopt AI, even if institutional capabilities are still lagging behind.

9. Overall Conclusion:

The study indicates a growing awareness of the importance of artificial intelligence (AI) in supporting urban development and applied geography in Libya, especially in light of the environmental and demographic challenges the country is facing. Although AI use remains in its early stages, with limited initiatives to date, it holds great potential in enhancing spatial analysis, future forecasting, and sustainable decision-making. However, AI adoption is hindered by several interconnected barriers, primarily the shortage of qualified personnel, weak infrastructure, and the absence of legal and regulatory frameworks. Therefore, this moment presents a strategic opportunity for policymakers to formulate a comprehensive national AI strategy—starting with human capacity building, followed by legislative reforms, and culminating in sustainable applications in urban planning and resource management, Table (3). The study emphasizes that investing in AI is a vital necessity for achieving sustainable urban development in Libya and calls for an integrated approach to ensure meaningful progress and improve quality of life.

Table3: *Integrated National AI Strategy for Urban Development and Applied Geography in Libya*

Strategic Axis	Objective	Key Components	Implementation Mechanisms	Responsible Actors
1. Human Capacity Building	Develop a skilled workforce capable of using and producing AI tools.	- Updating academic curricula in geography, urban planning, and computing. - Training programs for students, graduates, and professionals. - Fostering research in applied AI.	- Partner with universities and research centers. - Launch national training initiatives. - Establish AI-focused academic programs.	- Ministry of Education - Higher Education Institutes
2. Infrastructure & Data Ecosystem	Build a strong digital infrastructure to support AI applications.	- National spatial data infrastructure (NSDI). - Cloud computing platforms. - Real-time data collection systems.	- Digitize urban planning data. - Promote open data policies. - Collaborate with telecom and IT sectors.	Ministry of Communications Private Sector
3. Legal & Regulatory Reform	Provide a safe, clear, and enabling legal framework.	- AI ethics and data protection laws. - Regulations for AI use in urban governance. - Legal frameworks for geospatial data use.	- Establish a national AI regulatory authority. - Draft and adopt national legislation. - Conduct public consultations.	- Parliament - Ministry of Justice - AI Advisory Council
4. Pilot Projects & Applied Innovation	Demonstrate the real-world value of AI in Libyan cities.	- AI in urban mobility, waste management, and land use. - Climate risk mapping and disaster response. - Predictive modeling for urban expansion.	- Launch pilot projects in cities like Benghazi and Tripoli. - Collaborate with municipalities and local stakeholders. - Promote innovation challenges and hackathons.	- Urban Planning Authority - Municipalities
5. Public Awareness & Institutional Culture	Foster public trust and institutional readiness.	- Media campaigns on AI and sustainability. - Awareness sessions for planners and municipal leaders. - Promoting digital and ethical culture.	- Media partnerships. - Workshops and conferences. - Engage civil society and youth organizations.	- Civil Society Organizations - Media Institutions
6. Sustainability & Long-term Governance	Ensure the continuity and national ownership of the strategy.	- Establishing a national AI council. - Annual review and performance assessment. - Funding mechanisms for sustainability.	- Create a national AI roadmap. - Link AI strategy with national urban development plans. - Secure partnerships with donors and international institutions	- Research Centers - NGOs - International Agencies

Source: *Suggested by researchers*

10. Recommendations:

Based on the study results and the analysis of challenges and opportunities related to AI use in applied geography and sustainable urban development in Libya, the following recommendations are proposed to enhance the effectiveness and efficiency of adopting these technologies:

1. Upgrading digital infrastructure requires investment in high-speed networks and modern data centers capable of supporting AI and GIS technologies, enabling more effective spatial analysis and decision-making.

2. Capacity-building through specialized training and academic partnerships is essential to equip planners and researchers with the skills needed to apply AI in geographic contexts.

3. Developing accurate and updated spatial databases is vital for effective AI integration, including reliable data on population, environment, and infrastructure.

4. Clear legal and ethical frameworks must be established to govern the responsible use of AI, ensuring data privacy, transparency, and institutional accountability.

5. Promoting partnerships across sectors supports knowledge exchange and testing of AI applications through pilot projects tailored to local planning challenges.

6. Raising awareness and fostering a culture of innovation within institutions encourages acceptance of AI as a supportive tool, enhancing efficiency and sustainable development outcomes.

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