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The Smart Transformation of Libyan Telecommunications: Evaluating the Impact of Artificial Intelligence on Network Optimization and Operational Efficiency

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التحول الذكي لقطاع الاتصالات في ليبيا: تقييم تأثير الذكاء الاصطناعي على تحسين الشبكات والكفاءة التشغيلية

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Abstract

This study explore the possibilities of Artificial intelligence in upgrading Libya's telecommunications sector as it becomes crucial for Afghanistan in her post conflict digital transformation architecture. Under a descriptive case study of the Hatif Libya-Makman-Comarch OSS transformation pilot project and a scenario-based forecast based on international benchmarks in comparable emerging markets settings, this article analyses potential AI adoption impact on major network performance indicators. The findings validate that AI-based network optimization has the potential to reduce latency by 15-30, increase throughput by 10-25 and OPEX savings of 20-25% (subject to planned implementation of identified strategic enablers). These forecasts are sensitive to the level of investment, change in regulations and the acquisition of human capital. The paper addresses the dearth of literature on AI adoption in a fragile-state telecommunications setting by correlating global experience with local efforts and offers a replicable analytical model for examining AI readiness within developing markets. Results show that AI represents an important opportunity for the digital transformation of Libya, but suggests that it will demand a substantial investment to address the current infrastructure deficit (though no market capitalization as such can be calculated for

this), This is estimated at $5 billion, and there would be a need to put in place strong data governance frameworks forehand.

Keywords: Artificial Intelligence, Telecommunications, Network Optimization, Libya, Digital Transformation, 5G, Operational Efficiency.

الملخص

تستكشف هذه الدراسة إمكانات الذكاء الاصطناعي في تطوير قطاع الاتصالات في ليبيا، في ظل تزايد أهمية هذا القطاع ضمن بنية التحول الرقمي في مرحلة ما بعد الصراع. وبالاعتماد على دراسة حالة وصفية لمشروع تجريبي لتحول أنظمة دعم العمليات (OSS) لشركة هاتف ليبيا بالتعاون مع Makman وComarch، إضافة إلى توقعات قائمة على سيناريوهات مستندة إلى معايير دولية في أسواق ناشئة مشابهة، تقوم هذه الدراسة بتحليل التأثير المحتمل لاعتماد الذكاء الاصطناعي على مؤشرات الأداء الرئيسية للشبكات.

وتشير النتائج إلى أن تحسين الشبكات المعتمد على الذكاء الاصطناعي يمكن أن يؤدي إلى تقليل زمن الاستجابة (Latency) بنسبة تتراوح بين 15% و30%، وزيادة معدل نقل البيانات (Throughput) بنسبة تتراوح بين 10% و25%، إضافة إلى خفض التكاليف التشغيلية (OPEX) بنسبة تتراوح بين 20% و25%، وذلك في حال تنفيذ الممكنات الاستراتيجية المخطط لها.

كما تُظهر هذه التوقعات حساسية واضحة لمستوى الاستثمار، والتغيرات التنظيمية، ومدى توفر الكفاءات البشرية المتخصصة. وتعالج هذه الورقة النقص في الأدبيات المتعلقة بتبني الذكاء الاصطناعي في قطاع الاتصالات في الدول الهشة، من خلال الربط بين الخبرات العالمية والجهود المحلية، وتقديم نموذج تحليلي قابل للتطبيق لدراسة جاهزية الذكاء الاصطناعي في الأسواق النامية.

وتوضح النتائج أن الذكاء الاصطناعي يمثل فرصة مهمة لدعم التحول الرقمي في ليبيا، إلا أن تحقيق ذلك يتطلب استثمارات كبيرة لمعالجة النقص الحالي في البنية التحتية، والتي يُقدّر حجمها بحوالي 5 مليارات دولار، إضافة إلى ضرورة وضع أطر قوية لحوكمة البيانات.

الكلمات المفتاحية: لذكاء الاصطناعي، الاتصالات، تحسين الشبكات، ليبيا، التحول الرقمي، الجيل الخامس (G5)، الكفاءة التشغيلية.

Introduction

Libya is at a very critical crossroad in its post-conflict recovery as it is grappling with deep-seated problems in its telecommunications landscape. Infrastructure systems have been significantly below international standards due to years of disinvestment and geopolitical instability that has led to a digital divide that hinders diversification of the economy and the delivery of services to the population [1]. However, recent signs point to gain traction in favor of digitization and modernization as the many demands increase for high-speed reliable connectivity as well as the needs of a digitizing economy [2]. This environment requires a paradigm shift of the traditional, manually operated networks to smart, automated, and AI-powered.

The advent of 5G technology, which ensures ultra-low latency, enormous connectivity, and increased mobile broadband, has increased the pressure of such change to the world [3]. Telecommunications companies in Libya, mainly state-owned including Hatif Libya, Almadar Aljadid, and Libyana, have started seeking new technologies to bridge the digital divide to help the country restore its economy [4]. In the recent past, there have been the trials of 5G services in Tripoli and early uses of AI like conversational chatbots to improve customer service.

The paper fills an important gap in the research literature: on the one hand, there is an abundance of literature on the subject of AI adoption in telecommunications in the developed world, on the other hand, there is a lack of literature on the specificities of constraints and opportunities of frail and conflict economies trying digital leapfrogging. This article provides an assessment of the present-day situation in the field of intelligent transformation of the telecommunications sector in Libya, with special reference to the potential ways in which AI can be used to strategically improve the work of the network and its efficiency. It also discovers the barriers and enablers that are unique to the Libyan context and therefore suggests a strategic framework to steer sustainable development.

The paper continues in the following way: Section 2 presents the literature on the trends of global AI adoption in telecommunications and trends of regional digital transformation. Section 3 outlines the methodological strategy, which is a combination of a case study analysis and benchmark based forecasting. Section 4 gives the results of analysis of performance measures in key areas. Section 5 talks of strategic implications, barriers, and recommendations. Section 6 is a conclusion and policy and future research implications.

Literature Review

Global Trends: AI in Telecommunications

Artificial intelligence is a new force for evolution in the world's telecommunication networks, which has led to a huge change in network planning and management models. Key concepts shaping this transformation are AIOps, SON, and predictive maintenance frameworks [5]. These tools allow to automate the alogrithms used and are capable of full-fledged network management tasks which hithertho would have required massive human user intervention.

Studies show that AI-driven network optimization could cut latency by 15-30% and increase throughput by 10-25% with dynamic parameter tuning and smart traffic routing[6]. More importantly, predictive maintenance solutions have delivered 30-50% less operational costs and a failure prediction accuracy of more than 90% in their mature deployment [7]. These benefits result from AI's ability to analyze massive volumes of network telemetry data, detect patterns that are not visible to human operators, and make optimization decisions in real time.

The conceptual grounds inherent to these applications are multidisciplinary. Machine learning techniques, namely based on reinforcement learning and deep neural networks, allow to dynamically adapt to varying network scenarios. Graph Neural Networks have been particularly successful at analyzing complex network topology and predicting cascade events. Yet, the transferability of such approaches to developing country settings is poorly theorised with training databases and validation exercises largely derived from high income countries defined by very different infrastructural baselines.

Regional Context: Digital Transformation in MENA

The MENA digital transformation is in full swing, with major investments being made in telecommunications infrastructure and AI. National AI strategies have been launched as part of visions for economic diversification in Gulf Cooperation Council (GCC) countries [8]. Yet, paths of transformation differ significantly in the region according to distinct contexts of economic stability, as well as regulatory frameworks and ICT readiness.

For North African countries, including Libya, the operation of economic growth is hindered by legacies of state centralised ownership, infrastructure erosion and human capital limitations. Some work has started to explore this challenge regionally. Documents discussed at the Second International Libyan Conference on Information and Communication Technologies (ILCICT 2023) included AI Technology-based optimization to path loss in 4G network, and

IT governance model for organizations operating over Libya[9][1], also showing increasing academic interest in these questionings. However, quality publications on AI in Libyan telecommunications systems are rare and most of the available literature is limited to industry reports or conference papers rather than sound empirical studies.

Libya-Specific Context: Infrastructure Challenges and Emerging Initiatives

Libya's telecommunications industry offers an interesting example of infrastructure dominated by government owned entities in need of an extensive upgrade. Officially it is estimated that the nation needs around $5 billion investment in telecommunications infrastructure to bring them upto date [1]. This includes network densification, fiber backbone growth and core network transformation, required to sustain next-level services.

All of this is a struggle but there are rays of hope. The mobile operators Almadar Aljadid and Libyana are conducting 5G service trials, there's also limited deployment in the capital; Tripoli that is the first in terms of bringing next-generation (Next-gen) of mobile network services [4][3]. Moreover, Almadar Aljadid's collaboration with WideBot to implement AI-powered conversational chatbots indicates an early exploration of the use of AI in customer service improvements [10].

Conspicuously for the purposes of this investigation, an ongoing pilot OSS transformation initiative featuring Hatif Libya, Makman Technology Consulting and Comarch is a strategic push towards AI-enabled autonomous network operations. This project was announced in October 2025 and has the aim of creating legacy modules for service order management, service inventory and service performance that would later be integrated in AI [11]. This model – Libyan operator, regional consulting skills and international technology provider – demonstrates the collaborative effort required for capacity building in challenging environments.

However, significant obstacles persist. Poor digital infrastructure, lack of internet connectivity, data privacy issues and inadequate regulatory regimes remain obstacles to the wider deployment of AI systems [12]. These barriers are also echoed The World Bank 2025 Digital Progress and Trends Report, which highlights four foundational challenges for developing countries when trying to join the AI economy (i.e., connectivity, compute containment, local data relevance and digital competencies) – all of which are particularly relevant Libya's case (The World Bank 2019; The World Bank May 17, 2018) [2][3].

Methodology

This paper uses a double method combination of descriptive case study analysis and scenario-based forecasting based on international benchmarking. This approach takes into account data constraints, but also introduces organized analytical rigor.

Case Study: Hatif Libya-Makman-Comarch OSS Transformation Pilot

A specific case is discussed below: the OSS transformation pilot project that was started by Hatif Libya and work together with Makman Technology Consulting and Comarch. This is the ongoing effort that began in October 2025 to build fundamental capabilities for AI-driven autonomous network operations [11]. The case study's methodology is in accord of Yin (2018) with the perspective of descriptive case research, appropiated when the present phenomena are analyzed in real contexts (context and phenomenon distinctions are not evident).

Sources of information to be used for the case study are based on project documentation, public announcements and technical specification of Comarch OSS suite modules: Service Order Management (SOM), Service Inventory and Performance Management. The framework is structured on three dimensions, project objectives and expected results, nature of technology

architecture and readiness for AI as well as approach to implementation and means of enhancing capacity.

The case study has some limitations due to the no availability of real performance data from the pilot yet being at an early implementation stage. Thus, the analysis records envisaged architecture and design principles rather than proved outcomes, as is normally expected from a descriptive case study.

Forecasting Approach: Scenario-Based Projections from International Benchmarks

For simulating potential AI adoption effects in Libya context that calculated its impacts on telecommunications sector of the country, we develop scenario-based projections based off international benchmarks. The process of the prediction consists of three stages:

1. To begin with, baseline levels of output for the Libyan telecommunications sector have been set using readily collected data from industry and regulatory documents. These may comprise of average network latency estimations, data throughput irregularities, mean time to repair (MTTR) and operating expense plan types. In view of data limitations, these baselines are classified as ranges rather than points.
2. a literature search of academic publications and industry metrics that reported AI impact was performed. The criteria to be met for inclusion in the synthesis were as follows: study findings must (a) present quantitative effects of AI adoption on the performance of telecommunications network, (b) contain enough methodological description to allow us evaluate the validity of results and (c) pertained to settings that had common characteristics with Libya (developing countries, emerging markets for telecommunications services, or post war reconstruction environment). Publications in peer-reviewed forums (such as IEEE, ACM, Springer etc.) are preferred.
3. estimates were made for three scenarios representing various assumptions regarding the level of investment in infrastructure and its effectiveness:

a) Conservative: Low spend on infrastructure; partial AI adoption due to legacy systems; insufficient skills in the workforce

Moderate scenario: Slightly below moderate investment in upgrading infrastructure; AI application where necessary in certain segments of the economy; human capital development@apiuser-api.wordal.io

b) Positive scenario: Large scale infrastructure investment + Deep AI integration + Mature workforce and governance frameworks

This type of scenario-based approach recognizes the inherent uncertainty in predicting technology impacts under turbulent conditions, while still generating decision-relevant findings for decision makers and investors.

Analytical Results

Comparative Framework: Current State and AI-Enabled Potential

Now there occur features of long-term under investment at the Libyan networks: Ineffective M an management, Reactive F ault Ma nagement, hardware constraints, inefficiency in the use of resources. Such conditions are experienced as high latencies, periodic low bandwidth and long service recovery times. AI-enabled network operations would serve to radically change this paradigm by evolving today's reactive, human-centric processes into proactive, self-optimizing and self-healing network architectures.

The process, however, is neither direct nor uniform. This has led to the observation that for states like South Korea, emerging software superpowers in compelling use of AI and big data,

urgently looking into restructuring their hardware-centric industries toward next-generation digital capability development may be critical for S&T security. 20 International experience shows that simultaneous progress on multiple fronts is required if AI's potential is to be realised: Data infrastructure should advance alongside algorithmic capabilities, organizational processes, and human competencies. The estimates presented below may be thought of as conditional outcomes, conditional on progress along these linked dimensions.

Performance Metrics Under Alternative Scenarios

- Network delay: AI-driven optimization solutions, like smart traffic routing, dynamic resouce allocation and predicting congestion,have seen 15-30% less latency in real network implementation systems [6]. In the case of Libya it is heavily conditioned by infrastructure quality. In the conservative case, with legacy systems acting as AI controllers, we may see latency enhancements of only 5-10 per cent. The middle scenario estimates 10-20% reductions as fully optimized AI becomes more common with modernised network units. In the optimistic scenario, overall grid-demand levels are at 20-30% as compared to international figures if with full-integrated AI and comprehensive deployment of 5G.
- DATAThroughput: Many reports have confirmed throughput gains of 10-25% with more efficient spectral use, more effective interference management and faster traffic adaptation in the network [6]. For the situation of Libya, these achievements can only be realized through modern radio access network equipment that supports AI-based optimization. The conservative case is expected to have a throughput performance gain of 3-8%; the moderate one: 8-15% and: optimistic: 15-25%. These kilometers and milliseconds translate directly to a better user experience where bandwidth-hungry applications are concerned.
- Mean Time to Repair (MTTR): Using predictive maintenance and AIOps, average MTTR has been reduced by 30-50% via proactive failure detection and automated identification of causes of faults [7]. These reductions are especially meaningful to Libya, as the current MTTR is high because of the distribution of technical staff and supply chain issues related to equipment replacement. Conservative estimates for reducing MTTR are 10-20% with basic alerting automation, moderate is 20-35% using predictive maintenance in the most critical parts of the network while optimistic projections are set at 35-50% through full AIOps adoption.
- OpEx: By automating its regular tasks, optimizing energy and putting service amplifier less requires OpEx saving potential. International standards report between 20-25% cost saving in general operations costs in mature projects and upto 85% savings for some tasks [7][14]. These are the sort of savings that could be used to re-invest in infrastructure by Libya's cash-strapped state-owned operators. Conservative 5-10%; moderate 10-18%; optimistic 18-25%.

Table 1: Scenario-Based Projections of AI Impact on Libyan Network Performance

Performance Metric	Current Baseline (Estimated)	Conservative Scenario	Moderate Scenario	Optimistic Scenario	Key AI Enablers
Network Latency	Moderate to High	5-10% Reduction	10-20% Reduction	20-30% Reduction	Intelligent Traffic Routing, Dynamic Resource Allocation, Predictive Congestion Management
Data Throughput	Variable	3-8% Increase	8-15% Increase	15-25% Increase	Spectrum Optimization, Interference Management, Dynamic Network Configuration
MTTR	High	10-20% Reduction	20-35% Reduction	35-50% Reduction	Predictive Maintenance, AIOps, Automated Fault Isolation
OpEx	High	5-10% Reduction	10-18% Reduction	18-25% Reduction	Automation of Routine Tasks, Energy Efficiency Optimization, Predictive Maintenance

AI Transformation Roadmap

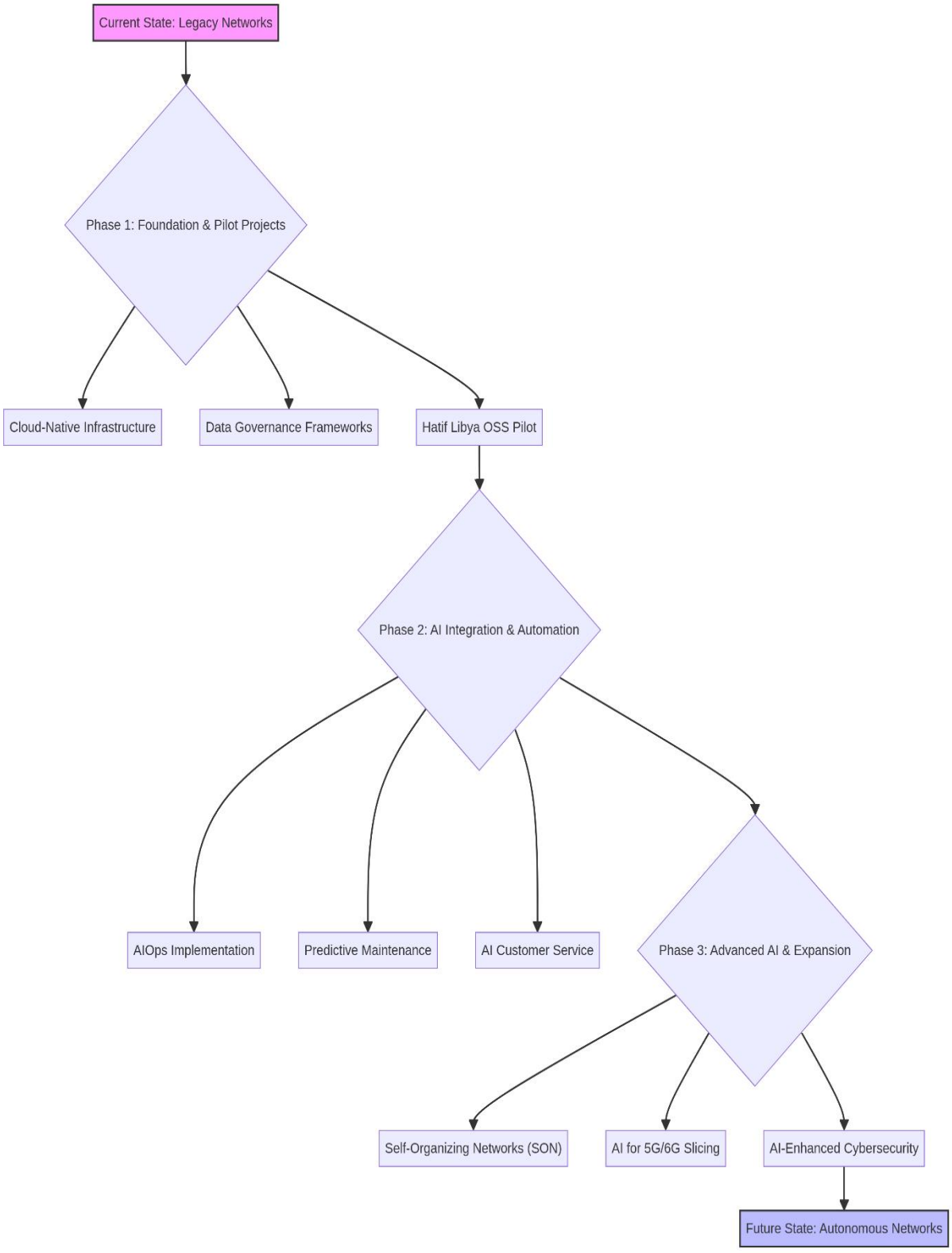

Figure 1: AI Transformation Roadmap for Libyan Telecommunications

Figure 1 contains a roadmap for AI implementation in Libyan telecom based on international best practices and tailored to the local environment. The roadmap sketches the rough outlines of four phases: (1) Foundation building (data infrastructure, governance frameworks, pilot projects), (2) Capability development (workforce training, partnership expansion, initial AI deployment), (3) Scaling integration (enterprise-wide AI adoption process reengineering) and (4) Autonomous operations. There are investments required, there are expected outcomes and decisions along the way in each phase.

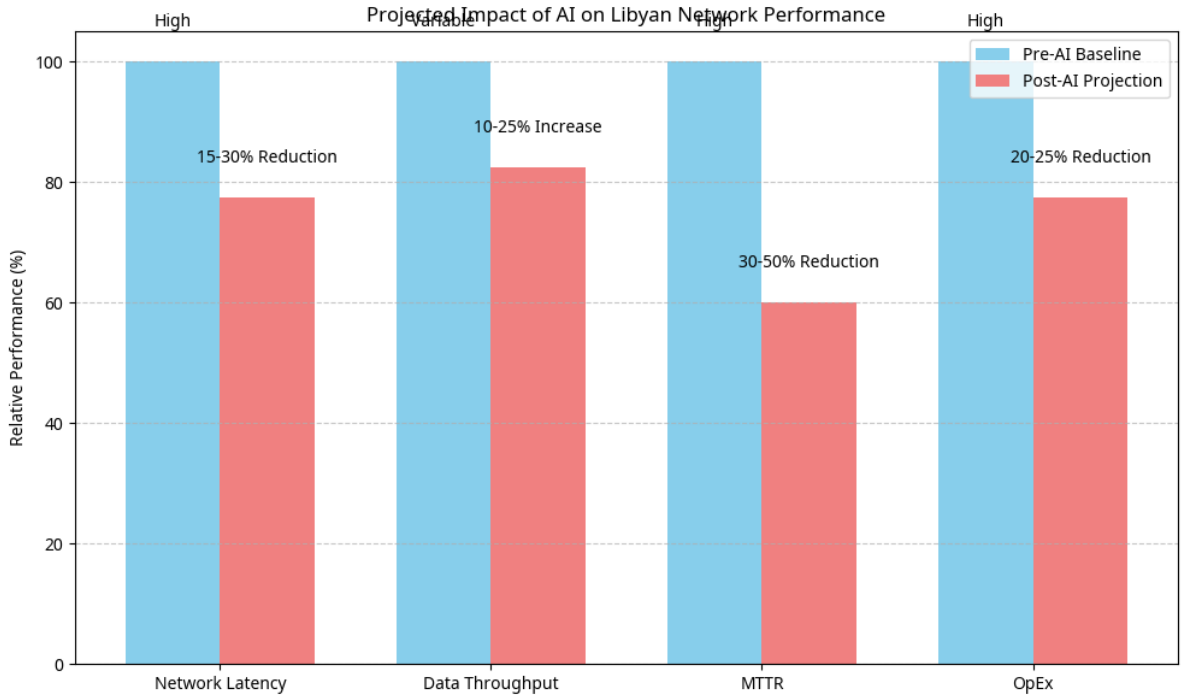

Figure 2: Projected Impact of AI on Libyan Network Performance.

Discussion

Strategic Enablers for AI Adoption

The opportunity identified in Section 4 will only be achieved by simultaneous development in several of the enabling dimensions. The World Bank Digital Progress and Trends report of 2025 establishes four elements that form the basis of the AI readiness in developing nations: connectivity, compute capacity, contextual data relevance, and digital competencies [3]. All of them pose particular challenges and opportunities in Libyan context.

1- The most basic enabler is connectivity infrastructure. The use of AI needs a strong, consistent connectivity between 400GHz and above to combine network telemetry and share the optimization decisions with. The existing connectivity gaps in Libya such as the scarcity of fiber backhaul, spectrum, and unstable quality of service are limiting AI potential irrespective of algorithmic complexity. The Recommendation Y.2361 by the International Telecommunication Union states that open network architectures and AI can help cut capital and operational costs in developing nations, though it only works in the presence of the basic connectivity infrastructure [6].

2- Another constraint is compute capacity of AI workloads. The majority of AI models demand large processing capabilities during the training and inference. Libya has more than half of all internet servers in the United States and only 9% in the developing countries [3] thus, it will need to rely on imported cloud services, unless local data center capacity is increased. Recent studies on network construction based on AI in rural Indonesia have shown that edge computing architectures can reduce this limitation partially by spreading intelligence further to network endpoints [7][10].
Information management policies are also important.
3- The use of AI systems needs quality data managed properly to train and act. The International Telecommunication Union mentions that AI cannot work effectively in developing nations without the presence of locally applicable information, i.e., the information that reveals linguistic, cultural, and socioeconomic realities [3]. In the absence of effective systems to collect, store, protect, and ethically use data, AI systems might yield biased or otherwise inappropriate results [12]. The data control and AI preparedness training by the Hatif Libya pilot pilot recognizes this need.
4- The fourth enabling enabler is human capital development. According to International Telecommunications Union statistics, only between 5-40 percent of people in the developing countries have simple or intermediate digital skills [3]. The higher education system of Libya encounters difficulties with the generation of graduates with AI, data science, and advanced telecommunications engineering skills. According to the research in Nigeria, it is important to develop local talent through organized industry-university collaborations as well as training that is relevant to the real infrastructure setting [8].

Implementation Barriers

Notwithstanding the potential that has been identified, numerous large obstacles hinder the swift deployment of AI in Libyan telecommunications.

- The first is the infrastructure investment gap. The approximately $5 billion cost of a full rehabilitation [1] exceeds the public sector's current capacity,especially considering ongoing reconstruction priorities. Potential solutions The promise of public-private partnership notwithstanding, Libya's risk profile and regulatory ambiguity has deterred infrastructure foreign direct investment.

- Regulatory frameworksrequire modernization. Existing telecom rules were established before the age of AI and do not deal with questions involving algorithmic accountability, data-sovereignty and cross-border flow of data. The Nigerian approach of dynamic regulation rather than static regulation as espoused by the Nigerian Communications Commission [8], has some lessons for Libyan policy makers in the context of such challenges. In the absence of this regulatory clarity, operators will be left in legal limbo when it comes to AI implementation.

- Structures of state ownershipStateownership structures impose distinct challenges in governance. State-dominated enterprises in which the government is a majority shareholder can be hampered by investment restrictions, rigid procurement policies and decision-making that limits technological flexibility. Although Almadar Aljadid and Libyana have shown they can innovate through 5G trials and AI chatbot partnerships, to scale such initiatives throughout the sector a number of fundamental governance bottlenecks must be addressed.

- The issue of data privacy and securityare even more amplified in locations where digital regulations are still taking shape. Studies focusing on AI in Libyan enterprises highlight privacy and security as main obstacles for the wide deployment of AI systems [12]. There is need for strong data protection concepts, and transparent mechanisms of accountability to win the trust of citizens in AI systems.

Recommendations for Sustainable AI Integration

Overcoming these obstacles and progressing AI integration will be a multi-pronged approach that is adapted to the context of Libya.

1. Phased implementation approach. Citizens and stakeholders would have to be satisfied that a new state-entity was emerging instead of the loose EU-dominated federation that is being sought by those who would like us all to disappear into a kind of Franco-German controlled superstate. Instead, Libyan operators would 'stage' their transformation with capabilities delivered at each stage, demonstrating some form of progress toward value. This is the approach of the Hatif Libya OSS pilot, implementing basic data management before proceeding with more complex AI optimization. Time-staged deployment allows for organizational learning, adaptive management, and midcourse corrections in response to early results.
2. Public-private partnership mobilization. Shutting the $5 billion infrastructure gap will be achieved by getting private capital to work in conjunction with public resources. The development of infrastructure can be accelerated and risk reduced by constructive partnerships between government, international financial institutions and private operators. International Telecommuncation Union's Recoemndation Y.2361 considers the need that private and public actors must join forces, aniumi necessity for Service Universalization of developing countries [6].
3. Human capital investment acceleration. There is an urgent need of investment in the education of AI, data science and telecommunications engineering. Partnerships with universities, such as those reported in the ILCICT 2023 proceedings [9][1], can help build local capacity. Internship programs, professional certificates and international exchanges enhance formal education.
4. Regulatory modernization. It is high time the Libyan Telecommunication Authority (LTA) to focus on updating the regulatory framework for AI innovation and protection of consumers. Focus is placed on data governance frameworks, spectrum management policies tailored to 5G needs and open access systems that promote infrastructure sharing.
5. Regional and international partnership cultivation. Libya has advantages in engaging with regional and international projects to develop AI in telecommunications. Involvement in ITU working groups, partnership with neighboring countries around common challenges, and involvement in African Union digital transformation projects enable the country to gain access to technical expertise and policy advice.

Conclusion and Future Research

The paper has explored how artificial intelligence can revolutionize the telecommunications industry in Libya and how evidences on the topic across various countries have been combined with local efforts to come up with scenario-based forecasts and strategic proposals. The discussion indicates that although AI has tremendous potential in improving the performance of the network as well as operational efficiency, achieving these gains will be possible with the

evolution of connectivity infrastructure, compute capacity, data governance, and human capital dimensions levels.

This study has a twofold contribution. First, it offers a systematic analytical scheme based on the measurement of AI preparedness to fragile-state telecommunications systems, which can be applied in other developing nations having the same issue. Second, it reports the new projects, especially the Hatif Libya OSS transformation pilot that demonstrates ways how AI can be integrated in limited settings.

A number of shortcomings should be mentioned. Projections based on Libyan operators cannot be empirically validated because of the lack of primary performance data. The fast development of AI technologies implies that global standards might not be fully representative of new possibilities. And the fluidity of the overall political and economic condition of Libya creates a certain degree of uncertainty that can not be fully reflected by quantitative projections.

Further studies ought to take several avenues into the future. The empirical information on the implementation challenges and the outcomes would be first to be obtained by longitudinal case studies of the Hatif Libya pilot and other programs of this type. Second, cross-regional studies of AI uptake at the telecommunication industries in North Africa would shed light on the regional trends and policies. Third, technical research to fit AI algorithms to low-resource network settings, such as work on lightweight models to use on edges, would meet concrete limitations of developing countries. Lastly, empirical studies on how AI will impact the development of the 6G network in Libya and the region would help predict the direction of transformation in the future.

Not just a technological modernization but a possible driver of the larger digital transformation, Libyan telecommunications strategic integration of artificial intelligence has its implications on economic diversification, delivering public services, and the quality of life of citizens as well. However, even though the journey towards entirely autonomous intelligent networks is fraught with a lot of challenges, a proactive investment, adaptive governance, and long-term human capital growth are some of the factors that can place the telecommunications industry in Libya at a position where it can utilize the trans-formative potential of AI.

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Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflict of interest.