Artificial Intelligence as a Mechanism for Achieving Sustainability in Algerian Startups

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Abstract:

Driven by targeted government initiatives fostering digital transformation, Algeria is experiencing a remarkable rise in innovative startups. Artificial intelligence has emerged as a critical strategic lever to significantly enhance enterprise performance and operational competitiveness. Beyond operational efficiency, AI acts as a foundational mechanism for achieving comprehensive economic, social, and environmental sustainability.

It drives these sustainable practices by optimizing data-driven decision-making, automating complex processes, innovating services, and rationalizing resources. However, widespread integration remains significantly hindered by weak digital infrastructure, limited funding, and an acute shortage of specialized talent.

Keywords: Artificial Intelligence, Sustainability, Startups, Innovation, Algeria.

JEL Classification: M13, L26, O33, C55, L86.

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1. Introduction :

Amidst the rapid transformations of the contemporary world, artificial intelligence has become one of the most prominent technological pillars driving economic development and enhancing organizational capabilities for innovation and adaptation within competitive environments. Its role is no longer confined solely to improving operational efficiency; rather, it has expanded to support sustainable development by optimizing resource utilization, rationalizing costs, and fostering data-driven decision-making.

In this context, startups emerge as a fundamental actor in propelling the national economy, particularly in Algeria, where these enterprises seek to adopt modern technologies—foremost among them artificial intelligence—to achieve growth and continuity in an environment characterized by change and uncertainty. However, achieving sustainability is no longer merely an option; it has become a strategic imperative compelling these enterprises to adopt innovative business models capable of reconciling economic, social, and environmental dimensions.

Consequently, the employment of artificial intelligence represents a promising mechanism for enhancing the sustainability of startups by supporting innovation, improving productive efficiency, and developing smart products and services that meet market needs in a sustainable manner. Nevertheless, this trend confronts a myriad of challenges, especially within the Algerian context, such as limited funding, a weak digital infrastructure, and a lack of specialized talent. This necessitates investigating ways to activate this role and maximize its impact on achieving sustainability.

From this standpoint, the research problem centers on the following fundamental question:

To what extent can artificial intelligence technologies contribute to enhancing the sustainability of startups in Algeria?

1.1. Sub-questions

- What is the role of artificial intelligence in supporting innovation and developing products and services within startups?
- How does artificial intelligence contribute to enhancing the various dimensions of sustainability (economic, social, and environmental) in startups?
- What are the most prominent challenges limiting the effectiveness of artificial intelligence as a tool for achieving sustainability under the current digital and legal environment in Algeria?

1.2. Research Hypotheses

- **First Hypothesis:** The use of artificial intelligence contributes to fostering innovation and developing new products and services, thereby supporting the competitiveness of startups.

- **Second Hypothesis:** Artificial intelligence plays an effective role in achieving sustainability across its economic, social, and environmental dimensions within startups.
- **Third Hypothesis:** The limitations of digital infrastructure and the shortage of specialized competencies in Algeria negatively affect the ability of startups to optimally utilize artificial intelligence as a mechanism for sustainability.

1.3. Research Objectives

This research aims to achieve a set of objectives, most notably:

- Elucidating the correlational relationship between artificial intelligence technologies and sustainability dimensions (economic, environmental, and social) in the context of startups.
- Revealing how artificial intelligence tools contribute to rationalizing resource utilization and reducing operational costs for Algerian startups.
- Diagnosing the reality of adopting artificial intelligence solutions in Algerian startups and determining the level of awareness among young entrepreneurs regarding their importance for achieving sustainability.
- Identifying the challenges and obstacles (technical and regulatory) that hinder the optimal utilization of artificial intelligence, and providing proposals to activate its role as a sustainability mechanism.

1.4. Significance of the Research

The significance of this research is manifested in the following aspects:

- Providing a conceptual framework that links artificial intelligence and sustainability within the context of the Algerian economy.
- Highlighting the importance of investing in innovation as an entry point for achieving sustainable economic growth in Algeria.
- Directing attention toward developing the digital infrastructure and enhancing training in the fields of artificial intelligence.
- Supporting decision-makers in formulating policies and strategies that promote the adoption of modern technologies within the entrepreneurial ecosystem.

1.5. Research Methodology

To achieve the study's objectives and ensure analytical precision, the descriptive and analytical approaches were adopted, as they are the most appropriate for the nature of the subject. The research seeks to describe the reality of artificial intelligence and startups while analyzing the intrinsic links between them, exploring the role of artificial intelligence technologies in achieving startup sustainability based on accurate data.

2. Conceptual Framework

The conceptual framework is a necessary foundation for understanding the various concepts associated with the subject of study, as it establishes the theoretical background upon which the research is built. In this context, this section presents an overview of the primary concepts, namely artificial intelligence and startups, as well as the concept of sustainability and its dimensions, aiming to clarify the relationships among them and highlight their role in achieving integration between innovation and sustainable economic development.

2.1. The Concept of Artificial Intelligence

Artificial intelligence is considered one of the branches of computer science through which artificial programs can be created and designed to simulate human intelligence. This grants organizations the ability to manifest their full potential and elevate it to the highest level, ensuring the efficiency and effectiveness of required business performance.

2.1.1. Definition of Artificial Intelligence

The final decades of the last century witnessed the emergence of an advanced technology that simulates human thinking, termed "Artificial Intelligence" (AI). The first appearance of this term dates back to 1955, when John McCarthy, a professor of mathematics at Dartmouth College in the United States, coined and officially introduced the term.

In the following year (1956), John McCarthy organized the Dartmouth Conference, which is considered the official launching point of this technology. The objective of the conference was to explore the possibilities of making machines simulate human intelligence (John & M, 2006, pp. 12-14).

Since that date, its scope of application began to spread and expand gradually, witnessing significant development in the twenty-first century as it encompassed multiple applications that assist humans in their daily lives.

Bartneck et al. defined it as "the ability of a machine or computing system to simulate and perform tasks that typically require human intelligence, such as logical reasoning, learning, and problem-solving" (Dahma & Ben Jeroua, 2025, p. 55).

It is also defined as "a part of computer science aimed at designing intelligent computer systems, meaning that they exhibit the same characteristics we associate with intelligence in human behavior" (Hachemi & Meliani, 2024, p. 50).

Furthermore, it is defined as "the technology that relies on a massive array of information and data provided by computers, software, and the internet, which can simulate human intelligence and even surpass it due to its capacity to learn, store information, and process problems correctly. This has made it a focal point of interest for enterprises across all sectors and activities of various types" (Arouf, 2025, p. 104).

Generally, artificial intelligence can be defined as "the cumulative efforts dedicated to developing computerized information systems in a manner that enables them to act and think similarly to humans. These systems can learn natural languages, execute physical tasks in seamless coordination, or utilize perceptual images and forms to guide physical behavior. Simultaneously, they can store accumulated human experiences and knowledge and employ them in the decision-making process."

2.1.2. Characteristics of Artificial Intelligence

Artificial intelligence technology relies on a set of core characteristics that enable it to achieve desired objectives efficiently and grant it a distinct advantage over other technologies. These characteristics can be summarized in the following key elements (Djabrit & Aichouch, 2024, p. 184):

- **Knowledge Representation Capability:** AI programs differ from statistical programs by using a specific structure to describe knowledge and establish a knowledge base that provides the greatest possible amount of information regarding the problem to be solved.
- **Use of Heuristic Search (Optimistic Experimental Approach):** These programs select a specific method for a solution that appears promising while keeping pace with potential changes. They do not rely on strictly sequential steps but rather prefer adopting the fastest solution.
- **Handling Incomplete Information:** These programs can process problems and find solutions even if the information is incomplete, owing to the massive volume of data they possess and through iterative processing.
- **Learning Capability:** AI technologies can improve their performance and learning capacity based on previous experiences and repeated practices, avoiding previously committed errors each time.
- **Reasoning Capability (Inference):** AI technologies leverage a vast amount of information and data stored within systems. Thanks to the expertise acquired through repeating certain scientific experiments, they have become capable of reasoning based on the laws of logic.

2.1.3. Types of Artificial Intelligence

Based on its capabilities, artificial intelligence can be classified into three distinct types, as follows (Zaamouki & Merzeq, 2023, p. 41):

- **Weak AI (Narrow AI):** Weak artificial intelligence is a type of AI capable of performing specific and clearly defined tasks, such as autonomous vehicles, or speech and image recognition software. This type is the most common and widely available form of AI today.
- **General AI:** This is a type that can operate with a capacity similar to human thinking. It focuses on rendering machines capable of thinking and planning autonomously in a manner analogous to human cognition.

However, there are no scientific examples of this type yet; everything that exists thus far remains confined to research studies requiring immense effort to develop and translate into reality.

- **Super AI:** Super artificial intelligence is a type that may surpass the level of human intelligence, capable of performing tasks better than a specialized and knowledgeable human. This type possesses several characteristics that it must inherently incorporate, such as the ability to learn, plan, communicate spontaneously, and pass judgments. Nonetheless, the concept of super AI remains hypothetical, with no actual existence in the current era.

2.2. The Concept of Startups

Startups are among the most prominent manifestations of the modern economy, creating added value by combining an entrepreneurial spirit with the exploitation of available resources, despite their limitations in early stages. These enterprises have witnessed widespread proliferation in recent years due to their vital role in manifesting creative ideas and transforming them into tangible projects capable of growth and development.

2.2.1. Definition of Startups

The emergence of the startup concept in the economic arena is linked to the development of venture capital and technological advancement, particularly during the post-World War II era. This term was first used in 1979 by researcher David Birch at the Massachusetts Institute of Technology (MIT) to refer to companies whose revenues exceed one million dollars, characterized by their ability to achieve rapid growth by doubling in size over a period of no less than four years. Since then, the concept has been widely used among researchers and decision-makers to terminologically denote enterprises embarking on a rapid growth trajectory driven by innovation and scalability (Wise & Feld, 2017, p. 05).

- Startups are enterprises characterized by their temporary nature, designed in a manner that enables them to achieve continuous and permanent development (Mebtouche, 2022, p. 114).
- They are newly established enterprises focused on providing an innovative product or service, designed for rapid growth and expansion within a large market. They are characterized by high adaptability and operate in an environment marked by uncertainty and high risk, aiming to achieve robust growth and substantial profits. They differ from traditional companies in their business model, which is founded on innovation and the search for new solutions rather than mere imitation or gradual expansion (Mekhancha, 2021, p. 771).
- A startup is a technology-based enterprise that employs a scalable business model by relying on continuous technological improvements underpinning its project, enabling it to create a new product or service. They are companies that aim to acquire a competitive advantage and create value, committed to developing their intellectual capital (Cai, Naveed, et al., 2020, p. 05).

Based on the preceding definitions, startups can be considered newly established enterprises fundamentally driven by creativity and innovation in delivering their products and services. Furthermore, they are characterized by their capacity for rapid and sustainable growth. Their founders possess an entrepreneurial spirit and a willingness to take calculated risks, allowing them to exploit available opportunities efficiently and strive toward a leading position within a highly challenging competitive environment.

2.2.2. Characteristics of Startups

Startups possess numerous characteristics that distinguish them from other enterprises, including the following (Bournan & Saouli, 2020, pp. 133-134):

- Startups are characterized by being newly established, young, and early-stage companies facing two choices: either developing and transforming into successful firms, or incurring losses and exiting the market.
- **Exponential Growth Potential:** This is one of the distinguishing features that define the meaning of a startup. This type of enterprise can generate high revenues in a very short time, far exceeding required costs. It possesses the capacity to conduct commercial activities rapidly, increasing its revenues and profit margins; its small size does not necessarily imply an inability to generate profit.
- **Reliance on Technology:** Startups are distinguished by conducting commercial activities based on pioneering ideas, satisfying market needs in a smart and modern manner. Startups rely on technology for growth and advancement, securing funding through online platforms and gaining assistance and support from business incubators.
- **Low Costs:** The definition of startups includes being a company that requires very low costs relative to the profits it generates, which usually materialize rapidly and unexpectedly.

2.2.3. Importance of Startups

The importance of startups lies in the following (Djabrit & Aichouch, 2024, p. 185):

- ❖ The creation of startups contributes to eradicating unemployment and providing job opportunities away from the classical pattern of government employment.
- ❖ Decentralizing and mitigating regional disparities across parts of the country by valorizing local resources and achieving integration and cohesion among regions.
- ❖ Encouraging individuals with innovative and entrepreneurial initiatives to enter the labor market and transform these ideas into independent, viable projects.
- ❖ Supplying local and national markets with products and reducing the import bill.
- ❖ Stimulating investment by embracing this type of enterprise, particularly in the field of modern technology.

- Increasing the Gross Domestic Product (GDP) and advancing the national economy through the financial returns they generate.

2.3. The Concept of Corporate Sustainability

Corporate sustainability is one of the modern concepts that has garnered increasing attention, particularly in the context of startups seeking growth and continuity within a competitive and dynamic environment. In this framework, sustainability is not limited strictly to the economic aspect; rather, it extends to encompass environmental and social dimensions, ensuring a balance between profitability and responsibility toward society and the environment.

2.3.1. Definition of Corporate Sustainability

Sustainability has become a top priority in the strategies adopted by most enterprises in the twenty-first century due to its long-term impact on their success—especially startups—and its alignment with the requirements imposed by the contemporary business environment. Today, the success and societal acceptance of enterprises are measured by the extent of their contribution to improving and preserving the environment, offering eco-friendly products that simultaneously meet customer needs and desires. It has become evident that the current use of the term sustainability represents a wide spectrum of mutual obligations and actions between enterprises across their various specializations and activities on one hand, and society through the daily practices of its individuals in all their forms on the other. These can exert a positive or negative impact on the facets and substance of the daily living environment and its continuity, ultimately reflecting on environmental sustainability. Recently, this has come to represent the strategic orientation of enterprises toward greening their operations and becoming more environmentally compatible.

Accordingly, corporate sustainability can be defined as "the developmental strategies adopted by enterprises to simultaneously achieve two objectives: first, supporting and backing the environment; and second, generating profit" (Al-Bakri & Bani Hamdan, 2013, p. 04).

This means that enterprises strive for positive compatibility with their surrounding environment, specifically the natural environment, as the primary source of inputs in their chain of operations. This stems from the premise that enterprises act as "citizens" dedicated to caring for, protecting, and avoiding harm to the environment, being an integral part of it. Concurrently, they seek to generate profit as a strategic objective to survive and continue.

It can also be defined as "the degree to which an enterprise actively and constructively utilizes its resources to support the socio-economic development of communities through direct monetary or in-kind investments, and through enterprise policies that generate social capital, such as reliance on local sourcing, partnerships, contracting, and education" (Bouzidawi, Lattoui, & Zabar, 2002, p. 73).

Furthermore, it is defined as "meeting the needs of stakeholders without compromising the enterprise's ability to meet those needs in the future" (Messaoudan & Belguidoum, 2022, p. 1435).

Based on the foregoing, corporate sustainability expresses an enterprise's capacity for long-term continuity and survival by adopting a forward-looking vision that is not restricted solely to generating economic returns. Rather, it extends to maximizing benefits for various stakeholders while actively minimizing the negative impacts of its activities, particularly on the environment and its natural resources. This arises from the enterprise's realization that its economic activity cannot be sustainable unless it takes into account both society and the environment as an indispensable framework for conducting its operations and ensuring its longevity.

2.3.2. Dimensions of Corporate Sustainability

The dimensions of corporate sustainability can be summarized in an interconnected tripartite framework reflecting the enterprise's relationship with various stakeholders, where sustainability is achieved through a balance between profit, society, and the environment. This is delineated as follows:

2.3.2.1. The Economic Dimension

The enterprise is an economic unit that conducts its various activities efficiently and effectively to create added value. It seeks to achieve maximum profit, enhance its value, and protect its assets through (Messaoudan & Belguidoum, 2022, p. 1436):

- Providing products of high quality at reasonable prices, ensuring safety during use, and continuously developing them.
- Committing to remediating damages that may occur post-sale and during usage.
- Adhering ethically to refraining from violating market business rules, such as engaging in monopolistic practices.

2.3.2.2. The Social Dimension

The enterprise is committed to providing the various elements that foster a sense of belonging and loyalty among its human resources. This is achieved by caring for their health conditions, developing their skills through continuous education and training, and offering a stimulating, safe work environment that elevates their performance level. It also strives to improve their social and cultural conditions and pays attention to their professional future even after their employment tenure ends.

The enterprise's role is not limited to its internal environment but extends to society as a whole by contributing to the creation of new job opportunities, assisting in reducing unemployment, and providing decent livelihoods. Additionally, it commits to respecting prevailing social values and customs, adopting positive behaviors that reflect its responsibility, alongside supporting social activities, scientific centers, and civil society organizations (Al-Amri & Al-Ghalbi, 2008, p. 98).

2.3.2.3. The Environmental Dimension

Given that the enterprise's operations rely fundamentally on the environment and its natural resources, it must work to protect and preserve them by adopting responsible practices aimed at curbing the environmental impacts resulting from its processes. This is embodied in maximizing resource efficiency, minimizing activities that may disrupt the long-term environmental balance, and implementing procedures and technologies that contribute to environmental protection (Messaoudan & Belguidoum, 2022, p. 1436).

3. The Role of Artificial Intelligence in Achieving Sustainability within Startups

The contemporary world is experiencing rapid development in the field of artificial intelligence, rendering it one of the primary drivers of transformation within enterprises, especially startups. Amidst the global orientation toward achieving sustainability across its economic, social, and environmental dimensions, the significance of employing AI technologies has emerged as an effective tool supporting this trajectory.

3.1. Artificial Intelligence and Achieving Economic Sustainability

Startups are the vital laboratory where artificial intelligence transitions from mere technical theories into sustainable economic solutions on the ground. While large corporations may find it difficult to overhaul their traditional systems, startups possess ample opportunity to build their business models around sustainability from day one. Below, we review the primary economic elements from which startups benefit through the use of artificial intelligence:

3.1.1. Reducing Operating Costs

Artificial intelligence plays a pivotal role in reducing operating costs by automating routine and complex tasks, thereby enhancing organizational profitability. By integrating AI systems, startups can automate repetitive processes such as data entry, quality checks, and customer service interactions, which traditionally require significant human intervention and resources. This transition not only reduces labor costs but also minimizes the likelihood of errors, leading to more efficient and reliable outcomes. Furthermore, AI-driven automation allows startups to scale operations rapidly without a proportionate increase in costs, as AI systems can handle increased workloads with minimal additional overhead. Consequently, adopting AI to automate production and commercial processes constitutes a strategic approach to achieving cost efficiency (Aifa, 2025, p. 12).

3.1.2. Increasing Productivity and Enhancing Competitiveness

AI technologies herald immense gains in increasing productivity levels and enhancing competitiveness for startups seeking to possess these intelligent systems. The latter enable heightened efficiency in production, maintenance, and supply chain operations, as well as product and service improvements. Moreover, these smart systems facilitate rapid and automatic adaptation to changing market conditions, the creation of new business models, and an improved balance between supply and demand with better forecasting and planning capabilities.

They also contribute to fraud detection, automating information and communication technology (ICT) functions, and optimizing sales processes (Artabaz, 2022, p. 1262).

3.1.3. Supporting Decision-Making and Strategic Planning

Integrating AI into organizational frameworks significantly enhances decision-making capabilities through comprehensive data analysis. AI technologies process massive volumes of data to identify patterns and insights that might be difficult for human analysts to discern, thereby facilitating more informed strategic decisions. For instance, AI-driven startups can analyze customer data to optimize product offerings and tailor marketing strategies, boosting business outcomes. Additionally, AI's ability to aggregate and interpret data in real time allows startups to adapt swiftly to market variables and consumer preferences, ensuring decision-making processes remain agile and highly responsive. By leveraging these analytical capabilities, startups can not only optimize their operations but also anticipate future trends, maintaining a competitive edge in an increasingly data-driven market landscape (Aifa, 2025, p. 13).

3.2. Artificial Intelligence and Achieving Social Sustainability

In light of rapid digital transformations, artificial intelligence is no longer merely an instrument for boosting profitability; it has become a fundamental driver for achieving social sustainability within startups. This relationship is manifested in the ability of these enterprises to employ smart technologies to innovate solutions that address pressing societal issues, such as improving access to education and healthcare, promoting financial inclusion, and creating qualitative job opportunities tailored to future skills.

3.2.1. Enhancing Digital and Financial Inclusion

Enhancing digital and financial inclusion is among the most critical societal roles played by AI-backed startups, helping bridge the gap between marginalized groups and essential services. Below, we review the key elements linking AI to the promotion of financial and digital inclusion in startups (Malik, 2025, p. 48):

- **Facilitating Access to Finance:** Utilizing alternative creditworthiness assessment algorithms for individuals lacking traditional banking records.
- **Microfinance:** Enabling startups to offer microloans to self-employed entrepreneurs and farmers based on precise risk analytics, supporting socio-economic sustainability.
- **Predictive Simulation:** Assisting individuals in visualizing their financial future and anticipating crises before they occur, reinforcing household financial stability.
- **Service Customization:** Providing smart user interfaces supporting local languages or catering to individuals with special needs, ensuring universal participation in the digital economy.

3.2.2. Creating Qualitative Job Opportunities and Skill Development

AI-reliant startups contribute to creating new jobs, particularly in digital domains, while enhancing individuals' skills and qualifying them for the modern labor market (Parhizkarkhadiv, Houshyaramiri, et al., 2025, p. 744).

3.2.3. Fairness and Transparency in Recruitment

Social sustainability is founded on "equal opportunities," and herein lies the role of technology in (Parhizkarkhadiv, Houshyaramiri, et al., 2025, p. 744):

- **Mitigating Human Bias:** Employing smart systems to screen resumes strictly based on technical skills, free from biases related to gender or social background.
- **Flexible Work Environments:** Providing smart tools for remote work management, supporting work-life balance and encouraging groups such as working mothers to participate in the labor market.

3.2.4. Improving Service Quality

AI technologies empower startups to deliver more efficient and accurate services, such as personalized e-learning and smart healthcare, thereby elevating the quality of life (Oyenuga, 2025, p. 03).

Quality no longer denotes merely an error-free service, but rather the degree of its alignment with individual user needs:

1. **User Behavior Analysis:** Employing machine learning algorithms to understand customer preferences and provide precise recommendations (as seen in e-commerce platforms or financial services).
2. **Anticipating Needs:** The ability to propose a service at the right time and place before the customer explicitly requests it, raising the level of "digital satisfaction."

3.2.5. Supporting Social Innovation

AI assists in designing innovative solutions to tackle complex social problems, such as poverty, unemployment, and poor services, through innovative business models led by startups (Abbas & Khalil, 2025, p. 09).

3.3. Artificial Intelligence and Achieving Environmental Sustainability

Artificial intelligence is a premier modern technology that has guided enterprises—startups in particular—toward adopting more environmentally sustainable practices. Confronted with mounting environmental challenges, such as climate change and natural resource depletion, it has become imperative to employ smart solutions that ensure a balance between economic growth and environmental preservation. In this context, startups leverage their agility and innovation capacity to utilize AI technologies in developing eco-friendly business models, including the following:

3.3.1. Rationalizing Resource Utilization

Rationalizing resource utilization constitutes the cornerstone of ambitious startup strategies seeking to combine economic efficiency with environmental responsibility. Unlike traditional industrial models based on linear consumption, sustainable startups rely on circular economy principles, deploying technology to minimize waste in energy and raw materials. This is achieved through (Tatar, 2025, p. 213):

- **Smart Input Management:** By utilizing AI algorithms, these enterprises can accurately forecast operational needs, preventing the procurement or consumption of resources exceeding actual demand, thereby reducing the carbon footprint resulting from overproduction.
- **Adopting Clean Energy Solutions:** Startups tend to design workflows relying on renewable energy or energy-efficient technologies (such as green computing), contributing to long-term operational cost reductions and ecosystem protection.
- **Value Recycling:** These companies innovate methods to transform waste or by-products of their operations into new resources, creating a closed loop that ensures the sustainability of natural resources for future generations (Abbas & Khalil, 2025, p. 09).

3.3.2. Supporting Green Innovation

Green innovation is the fundamental pillar allowing startups to combine technical development with ecosystem preservation. In the age of AI, green innovation is no longer merely an "ethical choice" but a competitive strategy to cut costs and attract global investments through:

- **Sustainable Design:** Employing smart simulation models to design products that are biodegradable or easily recyclable from the outset.
- **Material Substitution:** Searching for bio-alternatives to chemicals or plastics using chemical and molecular data analysis algorithms (Messaoudan & Belguidoum, 2022, p. 1439).
- **Smart Agriculture:** Innovating precise irrigation and fertilization systems that prevent soil degradation and conserve water, representing a core focus of green innovation in Algeria.

3.3.3. Reducing Waste and Emissions

Reducing waste and emissions represents the paramount environmental objective in sustainable startup strategies, where AI acts as an efficiency "maximizer," transforming environmental challenges into tangible economic opportunities. This is achieved through:

- **Smart Automated Sorting:** Employing computer vision technologies for highly accurate waste sorting in recycling centers, improving the quality of recovered materials and reducing volumes sent to landfills.
- **Optimizing Product Life Cycle:** Utilizing predictive analytics to anticipate equipment failures (predictive maintenance), extending asset lifespans and preventing them from turning into premature electronic waste (Messaoudan & Belguidoum, 2022, p. 1439).

- **Green Logistics:** Deploying algorithms to optimize routes and reduce shipping distances, cutting fuel consumption and associated emissions.

4. Requirements and Challenges of Adopting Artificial Intelligence in Algerian Startups

Artificial intelligence is garnering growing interest in the modern business environment, representing a strategic tool for fostering innovation and improving performance within startups. In Algeria, the significance of adopting this technology emerges as a fundamental entry point for supporting startup competitiveness and keeping pace with global digital transformations. However, this adoption is not without a set of requirements and challenges imposed by the nature of these enterprises on one hand, and the specificity of the socio-economic and technological environment on the other.

4.1. Requirements for Adopting Artificial Intelligence in Algerian Startups

The adoption of artificial intelligence in Algerian startups is witnessing heightened interest as a premier modern driver for innovation, performance improvement, and competitiveness enhancement. Nevertheless, this adoption does not occur randomly; it necessitates the availability of core prerequisites enabling these enterprises to effectively benefit from its technologies.

4.1.1. Technological Requirements and Data Infrastructure

The successful adoption of AI in Algerian startups hinges on the availability of a digital environment capable of locally hosting and processing big data. These requirements entail:

- **Data Centers and Digital Sovereignty:** Transitioning toward AI requires a robust cloud computing hosting infrastructure in Algeria. This requirement emphasizes utilizing data centers belonging to entities such as "Algérie Télécom," which provide a secure environment for sensitive data (ARPCE, 2024).
- **Data Governance and Quality:** The issue in Algeria does not lie in data scarcity but rather in its fragmentation (Data Silos). This necessitates transitioning from unstructured data to trainable Data Warehousing.
- **High-Performance Computing (HPC):** Accessing advanced computing capacities to train complex models, an asset the state seeks to provide through skill development centers and "smart universities."

4.1.2. Regulatory Requirements and Legislative Environment

The legal framework regulating AI usage mechanisms constitutes a fundamental pillar for ensuring digital trust, protecting intellectual property rights, and boosting investment attractiveness in emerging technologies. In this context, Law No. 18-07 relating to the protection of natural persons in the processing of personal data is the cornerstone regulating various AI-reliant activities in Algeria. It imposes strict controls on data collection, processing, and storage operations, partially aligning with international standards such as the European General Data Protection Regulation (GDPR) (Law 18-07, 2018).

Administratively and organizationally, obtaining the "Start-up Label" is a prerequisite enabling startups to benefit from various privileges, such as public funding and tax exemptions. This directly contributes to alleviating the financial burdens associated with developing AI solutions, particularly those requiring heavy investments in algorithms and digital infrastructure (Executive Decree No. 20-254, 2020).

4.1.3. Human Capital Requirements and Specialized Skills

The availability of technically and managerially qualified human competencies is among the most sensitive requirements for startups in Algeria. The matter is no longer confined to the simple utilization of digital tools; rather, it demands the capacity to locally develop intelligent models and engineer algorithms. This shift reflects the importance of possessing specialized human capital capable of keeping pace with rapid developments in the AI domain.

In this framework, the pivotal role of cooperation between startups and university research laboratories emerges as an effective mechanism for facilitating knowledge transfer and technology localization. Furthermore, the National Higher School of Artificial Intelligence (ENSIA) at the Sidi Abdellah pole represents a crucial model for specialized educational hubs. It contributes to preparing highly qualified competencies in fields such as data engineering and deep learning, supporting the needs of the startup market and reinforcing its capacity for local innovation and development.

4.1.4. Funding Requirements

AI projects require flexible funding models that move beyond traditional mechanisms like bank loans, shifting toward financing formulas centered on supporting long-term innovation and added value. This is due to the exploratory and uncertain nature of such projects, which require periods of development and testing before generating tangible economic returns.

In this context, the role of the Algerian Start-up Fund (ASF) emerges as an important public financing mechanism. It relies on a risk-sharing logic rather than tangible collateral, mitigating the financial burden on entrepreneurs and innovators during early development stages. This type of funding fosters a more conducive environment for incubating AI projects by enabling startups to translate their ideas into applicable solutions without excessive financial pressure (Zemit & Belhadef, 2024, p. 11).

4.1.5. Strategic Requirements and Digital Ethics

In the Algerian context, adopting AI within startups remains incomplete without a strategic vision aligned with national objectives and the establishment of an ethical framework governing human-machine relations. Therefore, it is imperative to steer these enterprises' projects toward what are known as "Grand Challenges" defined by the National Innovation Strategy, ensuring technological innovation aligns with the state's developmental priorities.

Within this framework, AI applications developed by startups should ideally align with priority sectors in the Algerian economy, enhancing their prospects of securing public support and boosting their capacity to meet market demands. Smart agriculture is among the most prominent of these domains due to its role in supporting food security, followed by digital health and renewable energies as highly promising strategic sectors (Guettaf, 2024, p. 465).

Moreover, relying on algorithms to make decisions impacting individuals—such as creditworthiness assessment or service provision—necessitates establishing stringent ethical rules that curb algorithmic bias and guarantee the principles of transparency and fairness. Consequently, building trust in AI technologies represents a prerequisite for the success of startups and the sustainability of their solutions in the economic environment.

4.2. Challenges of Adopting Artificial Intelligence in Algerian Startups

Despite the growing importance of AI in supporting innovation and enhancing startup competitiveness, its adoption in Algeria is not without challenges hindering its optimal proliferation. These enterprises confront difficulties relating to weak digital infrastructure, high investment costs in AI technologies, and a limited pool of specialized competencies capable of effectively developing and deploying these solutions. Below, we address these challenges in detail:

4.2.1. High Costs

The cost of developing and adopting AI is among the foremost challenges confronting startups in Algeria, given their limited financial and technical resources. Integrating this technology demands high investments encompassing model development and acquiring appropriate digital infrastructure, which can constitute a financial burden limiting these enterprises' ability to adopt it effectively.

This cost is also heavily tied to the need for massive, high-quality data, representing an additional challenge for Algerian startups, which often lack ready-made databases or the resources required for data collection, cleaning, and processing. Furthermore, these enterprises face difficulties attracting specialized competencies in AI and data analytics due to high recruitment and training costs. Therefore, the high cost of AI is not restricted solely to the technological aspect but extends to the various resources necessary for its adoption (Ben Nacer, 2023, p. 38).

4.2.2. Skills Shortage (Qualified Workforce)

Specialized human resources form the cornerstone for developing and applying AI technologies; concurrently, they represent a fundamental challenge for Algerian startups, particularly amidst limited financial and organizational capabilities. Adopting this technology requires highly qualified technical competencies, including programmers to develop models and algorithms, data analysts to extract knowledge from datasets, and experts who ensure the ethical and responsible use of these systems.

However, Algerian startups frequently find it difficult to attract these competencies due to their high costs, compounded by limited local expertise in this domain. This complicates recruitment processes and slows the pace of transition toward AI utilization in Algerian startups (Saouli, Ben Djeddou, & Ben Youb, 2025, p. 391).

4.2.3. Limited Funding

Adopting AI technologies requires substantial investments in digital infrastructure and specialized expertise, which are often unavailable to Algerian startups, particularly within an economic environment marked by instability and limited funding sources. These enterprises find themselves facing financial and technical challenges that hinder their ability to acquire advanced technological equipment or recruit the competencies necessary to develop and implement AI solutions (Dibi & Soufi, 2025, p. 481).

4.2.4. Weak Infrastructure

Weak digital infrastructure, particularly regarding data centers and cloud computing services, is among the most prominent challenges confronting Algerian startups in their AI adoption journey. The absence of an advanced infrastructure limits these enterprises' capacity to store and process data efficiently, negatively impacting the performance and development of intelligent models (Belatreche & Belatreche, 2025, p. 430).

4.2.5. Privacy and Security

The lack of a comprehensive legal framework and weak legislation concerning personal data protection constitute a genuine barrier to the adoption of AI applications by Algerian startups. By virtue of their newly established status and limited legal expertise, these enterprises may find it difficult to handle issues related to data privacy and individual liberties, especially in the absence of clear guidelines or ethical codes regulating the use of these technologies.

Furthermore, Algerian startups' reliance on AI for data analysis and decision-making heightens their responsibility toward protecting user information. This may expose them to legal risks or a loss of customer trust in the event of misuse. This challenge is exacerbated in an environment lacking an integrated regulatory framework capable of keeping pace with rapid technological advancements (Dibi & Soufi, 2025, p. 482).

5. CONCLUSION

In light of the structural transformations witnessed by the global economy toward digitalization, artificial intelligence emerges as a strategic lever capable of reshaping business models and reinforcing sustainability pillars within startups. This research has demonstrated that adopting these technologies represents an imperative choice rather than a mere optional trend, owing to their pivotal role in improving operational efficiency, supporting innovation, and enhancing adaptability to a dynamic competitive environment, fully aligning with economic, social, and environmental sustainability requirements.

However, the analysis revealed a clear gap between the theoretical potential offered by AI and its actual level of deployment within startups in Algeria. This deployment remains limited due to a set of structural constraints, foremost among them a fragile digital infrastructure, a weak innovation-directed funding ecosystem, and limited qualified human capital in AI domains. This confirms that the issue of sustainability is not linked solely to technology availability, but rather to the readiness of the economic and institutional ecosystem to embrace and activate it.

5.1. Findings

- The adoption of artificial intelligence technologies is a fundamental prerequisite for achieving sustainability in startups, where its role transcends the technical aspect to become a "survival strategy" within a shifting economic environment.
- AI algorithms contribute to enhancing the financial sustainability of Algerian startups by automating operations, improving operational efficiency, and reducing waste. This helps offset limited initial funding through cost rationalization.
- Relying on the predictive capabilities of AI elevates startup competitiveness, enabling them to analyze data with greater precision and deliver innovative products and services that sustainably respond to market needs.
- The challenges confronting startup sustainability in Algeria are not restricted solely to technical aspects; they extend to encompass the digital skills gap and weak infrastructure, hindering the optimal exploitation of AI technologies, particularly concerning big data processing.

5.2. Recommendations

- Enhancing investment in digital infrastructure by developing communication networks and data centers and expanding cloud computing services, providing a conducive technological environment that enables startups to adopt AI solutions efficiently.
- Supporting specialized education and training programs in the fields of artificial intelligence and data science, aiming to qualify human capital capable of meeting startup needs and keeping pace with digital transformation requirements.
- Providing innovative financing mechanisms specifically tailored for startups relying on smart technologies, focusing on risk-sharing funding models that support early development stages.
- Encaging the establishment of effective partnerships among universities, research laboratories, and startups, contributing to knowledge transfer, expertise exchange, and accelerating the pace of technological innovation.

- ❖ Developing a flexible, incentivizing legal and regulatory framework that keeps pace with technological advancements while concurrently guaranteeing personal data protection and building trust in the use of AI applications.
- ❖ Disseminating a culture of innovation and digital transformation within the Algerian entrepreneurial ecosystem by supporting awareness initiatives, fostering an entrepreneurial spirit, and promoting the use of modern technologies across various sectors.

6. References

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