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Artificial Intelligence and Business Process Management: A Responsible Framework for Sustainable Transformation

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Abstract

This study aims to develop a responsible and sustainable framework for implementing artificial intelligence (AI) in business process management (BPM), with a focus on aligning technological advancement with strategic economic transformation. It addresses the need for ethical, sector-sensitive AI adoption in emerging economies undergoing digital modernization and diversification. The research integrates enterprise information system considerations, privacy-preserving modular architectures, and national regulatory frameworks related to data localization and cybersecurity. A sectoral analysis is conducted to assess global AI adoption maturity and its implications for economic transformation, using Kazakhstan as a contextual reference point. The results reveal that consumer-facing sectors such as retail and financial services exhibit high near-term adoption potential, while healthcare requires gradual infrastructure and talent development. More significantly, mid-term opportunities in manufacturing, logistics, and transportation sectors present Kazakhstan with a comparative advantage. AI adoption in manufacturing is projected to grow by 83% within three to seven years, underscoring the importance of timely investments in automation, smart technologies, and workforce upskilling. This study contributes a context-aware framework for responsible AI-enabled BPM. It offers actionable insights for policymakers and business leaders in emerging economies, advocating for sectoral prioritization, strategic timing, and capacity-building to ensure sustainable digital transformation.

Keywords:

Business Processes;
Business Process Management (BPM);
Responsible AI; Data Science;
Artificial Intelligence (AI);
Enterprise Architecture; Data Protection;
Ethical AI; Process Improvement.

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1- Introduction

The architecture of business process management systems has developed quickly, producing vast volumes of data from the real-world implementation of business processes [1]. The ability to validate preexisting knowledge about how processes work or uncover new insights makes this data valuable. By introducing flexibility and permitting human intervention, when necessary, it also aids in the improvement of these procedures.

A business process is defined as a collection of tasks executed in a specific order to achieve the business goal. In other words, business process management systems monitor how processes are carried out to make sure they adhere to a set of guidelines. Applications of artificial intelligence (AI) give knowledge workers new opportunities to learn from data and offer more flexibility without sacrificing the proper operation of business processes. The application of artificial

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intelligence (AI) in businesses is expanding quickly. Building predictive models to foresee future events, creating predictive algorithms, and enhancing the creation, effectiveness, and delivery of goods and services are just a few of the numerous uses for artificial intelligence (AI) [2-4].

This application is frequently referred to as artificial intelligence and analytics (AI&A) in the business world. Managers particularly benefit from AI&A's assistance in gathering, organizing, analyzing, and visualizing vast amounts of data. They can make better decisions thanks to the helpful advice and insights it offers regarding their operations and business procedures [4]. Because businesses that use AI and analytics (AI&A) to leverage their business operations data typically achieve better performance, the use of AI in business process management is particularly pertinent today [5, 6]. The ability to use AI to manage operations has grown in importance for organizations, as noted by Balan et al. [7]. As a result, adopting AI&A approaches is crucial for enhancing business processes. There are significant worries regarding the use of data, even though organizations acknowledge the advantages of employing data analytics to enhance business procedures. There are risks associated with AI's power, especially in the areas of privacy, trust, and fairness [8]. AI initiatives occasionally yield biased or inaccurate results, which could be against the law or damage a company's reputation. Biased algorithms, biased data, or negligent handling of both can result in these issues [9].

Sensitive information may be accidentally shared or misused by others, and decisions based on data may be unfair or opaque [10]. When using AI, it's crucial to identify and stop bias and discrimination because businesses must uphold legal requirements and safeguard their reputation. For instance, the General Data Protection Regulation (GDPR) of the European Union requires accountability and transparency when handling personal data.

All phases of digitalization must be gradually completed, starting with basic automation, for AI to be used methodically in businesses. There are many similarities among the basic methodologies, even though the specific approaches may vary in practice. The work of Blanchard & Taddeo [9] offers a representative example of this approach. When AI is used to support business processes and their management, it is crucial that these processes function as planned and have the capacity to reverse or recover from any unintended or inconsistent outcomes [11, 12]. This is where tools like business intelligence interfaces and interactive dashboards come in very handy. By addressing problems and suggesting fixes, they assist in keeping an eye on and modifying business procedures. These tools give knowledge workers useful options and insights into the ongoing processes, frequently exposing previously unobtainable information.

Business process management systems need to be able to communicate with different agents in an efficient manner to fully realize AI's potential. Businesses and organizations, particularly those in Kazakhstan, find it especially difficult to implement big data-driven business processes because their current information systems were not designed to handle or organize massive amounts of data. Furthermore, it's possible that many businesses lack the management frameworks required to evaluate large data and transform it into insightful information that can be used.

More than just technology is needed to make the transition to data-driven business process management; it also calls for trained staff who can use AI efficiently, modifications to system architectures to facilitate data collection and analysis, and a more general shift in organizational mindset [13]. Establishing ecosystems for data-driven innovation is essential and building a successful data commons require a thorough examination of several facets of the data economy [14].

Offering fresh and in-depth perspectives on how procedures are carried out, as well as suggestions adapted to process objectives and actions depending on the circumstances, can help Kazakhstan improve its business processes. These recommendations ought to be tailored to each business user's preferences and profile. Additionally, the information offered should change according to the user's type and the situation in which they are using the system.

However, inappropriate AI implementations run the risk of violating privacy and resulting in systematic discrimination [15]. Therefore, it is essential to avoid any negative effects that data misuse may have in any setting, as well as to prevent non-transparent and inaccurate outcomes [16].

The following fundamental guidelines must be adhered to in Kazakhstan's responsible application of AI in business process management [16]:

- ***Fairness:*** AI results should steer clear of biased or unfair conclusions, even if they appear to be statistically correct.
- ***Accuracy:*** AI systems must produce accurate and trustworthy results, not merely educated guesses.
- ***Confidentiality:*** AI should respond to queries without disclosing private or sensitive data.
- ***Transparency:*** The system must provide users with intelligible and significant explanations of the decision-making process.

Following these guidelines is crucial to fostering ethical, responsible use of AI applications in Kazakhstani businesses. The Expert Group on Artificial Intelligence has identified global trends that are consistent with Kazakhstan's shift toward human-centric AI systems. The ethics guidelines that support trustworthy AI technology that upholds human rights,

refrains from discrimination, and guarantees responsible use are emphasized in the new European Union regulatory framework for AI products and services. Adopting comparable ideas is essential for Kazakhstan to create trustworthy and accountable big data and AI-based business processes.

New data sharing techniques that prioritize privacy protection have also been introduced by recent studies. Additionally, intelligence analysis research has pinpointed issues and offered useful suggestions for how businesses can resolve them. Adhering to these global ethical frameworks will be crucial as Kazakhstan advances its digital transformation to promote innovation, safeguard privacy, and increase public confidence in AI technologies [17].

Ensuring adherence to laws governing the use of AI and personal data is another crucial factor in Kazakhstan's responsible AI implementation. For instance, the General Data Protection Regulation (GDPR) in Europe, which went into force in 2018, imposes stringent guidelines on how businesses handle personal data. These guidelines apply to both European businesses and any organization that handles the data of European citizens.

Recent scholarship has advanced our understanding of AI in BPM, with studies highlighting the transformative potential of AI for organizational efficiency, innovation, and competitiveness [18-21]. These studies have explored various aspects, including the integration of AI into enterprise systems, the role of data governance, and the ethical challenges associated with responsible AI adoption. However, literature remains limited in several respects. First, there is a lack of comprehensive frameworks that address responsible AI implementation in BPM within the context of emerging economies, where regulatory environments, digital infrastructure, and sectoral readiness differ significantly from those in developed countries. Second, existing research often overlooks the interplay between national data localization laws, cybersecurity regulations, and privacy-preserving system architectures, which are critical for sustainable AI adoption. Third, sector-specific analyses of AI adoption maturity and its impact on economic diversification are scarce, particularly for countries transitioning from resource-based to knowledge-driven economies.

To address these gaps, the present study proposes a responsible implementation framework for AI-enabled BPM, tailored to the unique context of Kazakhstan. By synthesizing insights from enterprise information systems, privacy-focused modular architectures, and national regulatory requirements, this research provides actionable guidance for policymakers and business leaders. The framework is further informed by a sectoral analysis of AI adoption maturity, highlighting opportunities and challenges in manufacturing, logistics, transportation, energy, and consumer-facing industries. In doing so, this study contributes to the literature on responsible AI in emerging economies and offers practical strategies for sustainable digital transformation.

The implementation of transparent and accountable AI systems, particularly when handling sensitive personal data, is a similar challenge for Kazakhstani organizations. Establishing transparent laws and frameworks that safeguard privacy and encourage ethical AI use is essential as Kazakhstan develops its digital economy. Next section reviews the theoretical approaches underpinning responsible AI adoption in business process management. To facilitate responsible and reliable business process management and improvement specifically for Kazakhstan, we start this article by suggesting an information system design. Next, we go over the main research questions, lingering difficulties, and possible directions for future research in this field. We analyze Kazakhstan’s national AI readiness priorities and the integration of AI-enabled BPM, drawing lessons from sectoral leadership and early adoption experiences. Lastly, we outline pathways to success with AI in Kazakhstan’s business environment, with a focus on investment targeting and timing. Reflections on unanswered questions and recommendations for future research directions are included in the paper’s conclusion.

1-1- Theoretical Approaches

This study adopts a multidisciplinary theoretical approach that integrates concepts from Business Process Management (BPM) theory, Responsible AI frameworks, and Technology Adoption Models, with a contextual emphasis on institutional theory and strategic alignment in emerging economies. At its core, the research is grounded in BPM theory, which views business processes as structured, measurable activities designed to produce specific organizational outcomes. The integration of AI into BPM is examined through the lens of process innovation and digital transformation, where AI is not merely a tool for automation but a catalyst for rethinking workflows, decision-making, and value creation.

To ensure ethical and sustainable implementation, the study draws on Responsible AI frameworks, particularly those emphasizing transparency, accountability, fairness, and data governance. These principles are operationalized through the design of privacy-preserving modular architectures and compliance with national regulations on data localization and cybersecurity [22, 23].

The research also incorporates elements of the Technology-Organization-Environment (TOE) framework and the Diffusion of Innovations (DoI) theory to assess sectoral readiness and adoption maturity. These models help explain how organizational size, regulatory environment, and technological infrastructure influence the pace and scope of AI adoption across sectors. Additionally, the study is informed by institutional theory, which highlights the role of formal

rules, norms, and governance structures in shaping technology adoption in public and private sectors. This is particularly relevant in the Kazakhstani context, where regulatory frameworks and state-led digital strategies play a central role in shaping innovation trajectories.

Finally, the concept of strategic alignment is used to evaluate how AI-enabled BPM initiatives can be synchronized with national development goals, such as economic diversification and digital modernization. This alignment is critical for ensuring that AI adoption contributes not only to operational efficiency but also to long-term socio-economic resilience.

2- Information System Architecture for Kazakhstani Data-Driven Businesses

Kazakhstani businesses require sufficient tools, techniques, and technologies to support governance and well-informed decision-making for AI to be used responsibly and credibly within business process management, particularly when it is based on big data [24]. Together, these elements, which include technical solutions and governance frameworks, must guarantee that ethical AI principles are applied throughout the entire business operations data analysis process.

2-1- Enterprise Information Systems in Kazakhstan: Market Trends, AI, and Digitalization.

Kazakhstan's enterprise information systems (EIS) landscape has changed significantly in recent years due to a national agenda to modernize infrastructure, integrate AI into key processes, and strengthen the country's digital economy to promote sustainable economic growth [25]. To foster innovation, establish a cohesive national AI platform, and establish the nation as a competitive regional leader in the adoption of digital technologies, the government unveiled an ambitious 2024–2029 AI Development Strategy by 2024. The state's understanding of EIS as strategic assets necessary for increasing productivity, facilitating data-driven decision-making, and promoting new business models is reflected in this strategy.

The modernization of communication infrastructure has been a significant turning point in this change. The digital divide between urban and rural areas was greatly reduced as more than 3,700 government and budgetary organizations were given access to high-speed broadband and more than 1,200 rural communities were connected to the internet. More inclusive participation in the digital economy is now possible thanks to these infrastructure improvements, which have also improved the population's digital literacy and the accessibility of both public and private digital services [26]. Because they increase the potential user base and enable real-time data exchange across geographically disparate locations, such advancements are especially pertinent to enterprise systems.

One notable feature of Kazakhstan's digital transformation is the widespread use of e-government services. An estimated 93.3% of all public services would be accessible online by 2024, with 86% of those services being available via smartphones [27]. This high level of mobile accessibility demonstrates the government's dedication to providing user-centred services and is consistent with international GovTech best practices. Platforms like the E-Appeal system and the Government for Citizens portal have simplified communications between the public, private sector, and the government, lowering red tape and boosting openness. The efficiency and responsiveness of the public sector could be further maximized by integrating these platforms with new AI capabilities.

At the same time, Kazakhstan's digital payment and e-commerce ecosystems have grown quickly. A significant portion of online transactions now take place on marketplaces, which provide a practical interface for both buyers and sellers while reflecting worldwide consumer trends. EIS are becoming increasingly integrated into consumer and business processes, as evidenced by the growth of neobanking solutions, the adoption of Buy Now, Pay Later (BNPL) models, and the diversification of B2B digital platforms that support accounting, legal, HR, and billing services. Strong market competition supports this evolution, as shown by shifts in search engine usage patterns. In 2024, Yandex's market share increased to 23.2%, while Google's market share decreased by 16.5 percentage points, demonstrating a dynamic and locally adaptive digital ecosystem [26].

Rankings of the world's digitalization also show Kazakhstan's progress. The nation scored 66.03 out of 100 in the 2024 IMD World Digital Competitiveness Index, placing it 35th out of 63 economies and demonstrating a consistent improvement in talent, technology integration, and digital infrastructure [28]. Kazakhstan's leadership in online service delivery was highlighted by its ranking of first among CIS nations and 24th globally in the UN e-Government Survey. Furthermore, the nation's ranking of 58th in the Network Readiness Index and among the top 50 in the ICT Development Index highlight a strong basis for future EIS innovation.

The private IT industry is essential to maintaining this trend. Big businesses like Aviata, Kolesa Group, ChocoFamily, and Kaspi.kz have created integrated digital ecosystems that combine e-commerce, financial services, and mobility solutions. More than 1,500 IT companies, including over 400 that involve foreign investment, are currently housed in Astana Hub, the country's largest technopark, which provides tax breaks, incubation assistance, and international networking opportunities [29]. In addition to providing IT education for over 18,000 specialists, Astana Hub has

generated 40.5 billion tenge in revenue since its founding, directly addressing the talent gap that continues to be a major issue for the industry.

Nevertheless, several structural issues still exist despite these developments. The adoption and innovation of EIS could be slowed by a lack of skilled IT workers. Concerns regarding data protection and operational resilience have increased as cybersecurity risks have increased in tandem with the expansion of digital transactions [30]. Disparities in access to and use of technology are a result of digital inequality, which still affects older and rural populations. Furthermore, legal frameworks have found it difficult to keep up with new technologies, which has occasionally slowed the quick adoption of creative business models.

All things considered, Kazakhstan's enterprise information systems are currently experiencing rapid expansion and strategic alignment with worldwide digital trends. A favourable climate for the modernization of business process management has been established by the combination of robust government vision, infrastructure investment, active private sector innovation, and developing AI integration. To make this transition inclusive and long-lasting and establish Kazakhstan as a digital leader in Central Asia, it will be imperative to address the remaining human capital, security, and regulatory issues.

2-2- The Significance of Modular Architecture That Prioritizes Privacy

According to information systems (IS) research, Kazakhstani businesses are under increasing pressure to innovate constantly and maintain their competitiveness on a local and international level. As a result, IS systems are "never complete" and need constant improvement and refinement [31-33]. Reexamining current socio-technical structures is necessary to develop big data-based business process governance that works. This entails implementing new decision points that are based on data insights produced by artificial intelligence techniques. Organizations' operational management is altered by these new strategic decision points, which leads to the creation of new, stable socio-technical configurations. Management platforms must be redesigned in accordance with the needs of adaptation, going through cycles of stability and flexibility until an improved IS configuration is obtained.

An integrated framework for the governance of business process management (BPM), incorporating big data analytics, artificial intelligence, and emerging sociotechnical constructs, is illustrated in Figure 1. The framework integrates evolving decision structures and feedback mechanisms that reflect the dynamic nature of information systems (IS) over time. It is grounded in the premise that information systems are never complete, which serves as the initiating condition at the top of the framework. This perspective highlights the need to account for new BPM dynamics that capture changing operational workflows, alongside new strategic decision processes that shape long-term organizational direction. These two dimensions emerge as parallel governance streams within the framework [34].

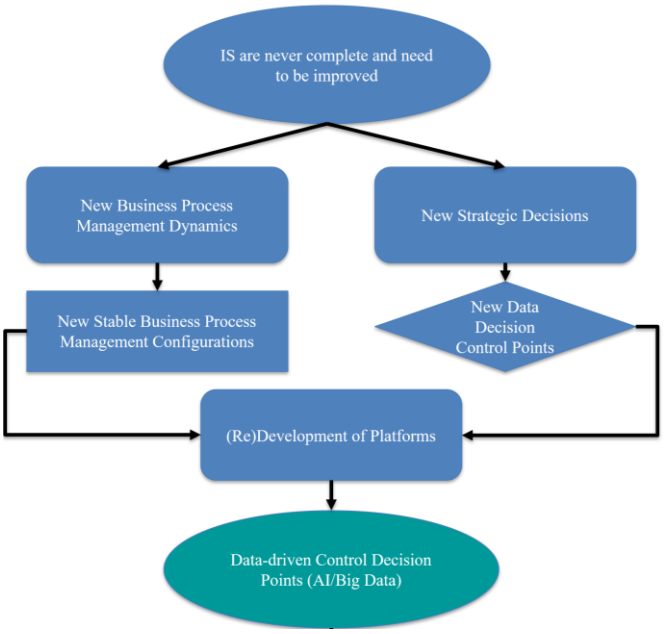

Figure 1. Governance of business process management integrating sociotechnical constructions and AI-driven decision points

New Stable BPM Configurations, which stand for improved operational states, and New Data Decision Control Points, which implement strategic decision-making based on real-time, massive data inputs, are the two separate but interconnected components that result from the convergence of these streams. The latter's function in identifying potential courses of action is highlighted by its modeling as a decision node. Both routes contribute to the

(Re)Development of Platforms, a phase that involves iteratively updating process design and technology infrastructure [33]. Data-driven Control Decision Points, which use AI and big data analytics to improve governance outcomes, directly inform this stage.

The framework reinforces the idea of continuous evolution by explicitly incorporating feedback loops from the AI/data-driven stage back to the initial IS improvement stage. While shape variations (ovals, rectangles, and diamonds) differentiate between start points, processes, and decision points, arrows and flow directions show causal and informational linkages. In addition to operationalizing sociotechnical viewpoints on BPM governance, this setup emphasizes the importance of AI and big data in complex, adaptive systems' decision-making process.

In Kazakhstan, this iterative process necessitates not only technological advancements but also human capacity building and organizational culture adaptation to successfully integrate AI-driven decision-making. It will be critical for Kazakhstani businesses seeking to responsibly use AI in their operations to align these socio-technical changes with national digital transformation goals.

When creating a new information system (IS) in Kazakhstan to facilitate the execution of business processes, the system architecture must be modular, divided into manageable components, and adhere to simple design principles. The way the IS used and managed in regular business operations must be closely matched with this design. Therefore, data and the use of AI based on operational data should drive important decision points and control mechanisms.

The environment in which the business operates, including pertinent legal frameworks, societal well-being, privacy and security requirements, and Kazakhstani market principles, influences how the IS organized. For instance, Kazakhstan is increasingly creating its own laws to guarantee data security and privacy in accordance with international standards, even though the European Union's GDPR requires a privacy-by-design approach for any IS handling personal data. To guarantee responsible AI use and to safeguard the rights and interests of all stakeholders, such regulatory considerations must be incorporated into IS design from the very beginning.

Businesses in Kazakhstan that want to implement ethical AI governance begin by establishing, in accordance with established standards, the moral standards that will direct their operations and that they pledge to adhere to. To review and approve AI strategies, especially those pertaining to the company's own operations, companies should ideally form an ethical board with important members like ethicists.

Our framework states that a well-defined governance structure is crucial. This structure ought to be founded on the data gathered and the use of AI, with clearly defined roles outlining who decides on various business operations matters, including any advantages or disadvantages found by AI analysis.

The IS Architecture is depicted as a central core that is split into two interconnected hemispheres in Figure 2, which shows a dual-sided framework. A modular and decomposable IS architecture is the focus of the left hemisphere, Internal Fit: Simple Design Rules. Three integrated elements New Decision Points, Control Mechanisms, and Data-Driven Decisions for Business Processes are connected to this core by outward-radiating arrows, emphasizing their interdependence and the value of an adaptable internal structure [35].

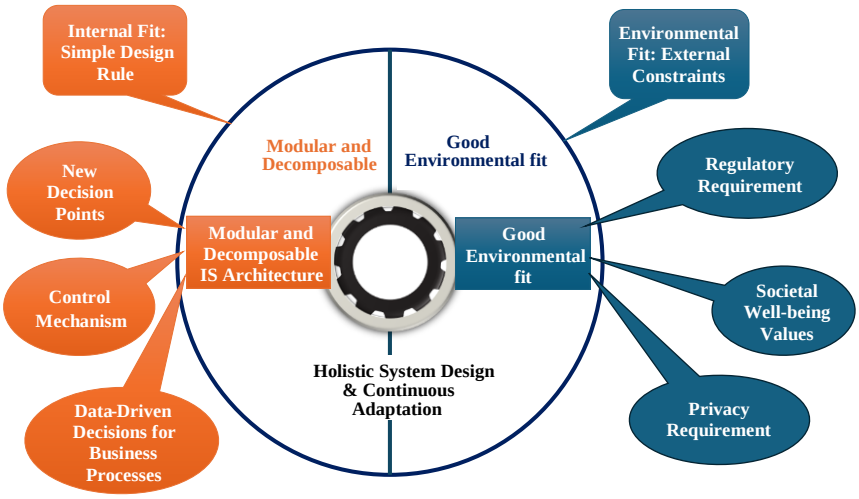

Figure 2. IS architecture balances internal fit through modular design, decomposition, and simple rules enabling new decisions, controls, and data-driven processes with environmental fit to regulations, societal values, privacy, and market principles

Alignment with external factors is the focus of the right hemisphere, Environmental Fit: External Constraints. Four major influences market principles, societal well-being values, privacy requirements, and regulatory requirements—are

connected to a Good Environmental Fit core by inward-pointing arrows. The interconnectedness of these constraints is shown by interlinking lines. The two hemispheres are integrated at the center by a bold connector called Holistic System Design & Continuous Adaptation, highlighting the fact that both strong internal design and external alignment are necessary for effective IS architecture.

2-3- Considering Data Localization Regulations and Kazakhstan's Cybersecurity Laws

Implementing AI-enabled business process management (BPM) solutions is directly impacted by Kazakhstan's regulatory framework, which places specific restrictions on where and how personal and specific service data must be processed, stored, and safeguarded. Organizations are generally required to maintain databases of personal information and specific electronic records on servers situated in Kazakhstan under the national Data Protection and Informatization regimes. Additionally, sectoral instruments, such as ministerial orders and communications rules, specify storage and service-information retention obligations [36, 37].

Due to these practical localization requirements, businesses using AI in BPM must either host data on domestic infrastructure (local cloud regions or on-premises) or (b) adhere to specific exemptions and procedural requirements for cross-border transfers. Additionally, the regime creates operational dependencies between hosting choices, domain registration, and regulatory oversight by linking storage obligations to obligations for information system protection, as well as for the registration and operation of national domain resources.

At the same time, Kazakhstan maintains a well-established cybersecurity ecosystem that requires timely reporting of security incidents to state authorities and requires information-security measures for operators of informatization systems [38]. This ecosystem is anchored by national incident-response capabilities and regulatory reporting duties. Because AI systems frequently rely on big datasets and outside services, these regulations make compliance more difficult. As a result, they need to exhibit strong encryption, access controls, logging, and incident-response preparedness [39].

The regulatory environment translates into specific design requirements for researchers and practitioners implementing responsible AI in BPM: certified local processing or local data residency; explicit contractual and technical controls for any third-party processors; documented policies for data minimization and retention; privacy and security impact assessments; and tested incident-response procedures that comply with national reporting regulations. It will be crucial to incorporate these controls into governance frameworks and system architecture in order to guarantee legal compliance and facilitate Kazakhstan's adoption of scalable, reliable AI.

3- Implementing Responsible Use of Big Data and AI

According to IBM, responsible artificial intelligence (AI) is a set of guidelines intended to control the creation, application, and deployment, and use of AI systems with the goals of promoting social trust, abiding by legal and ethical requirements, and minimizing risks while optimizing rewards. Building trust in AI solutions that have the potential to empower organizations, and their stakeholders is made possible by a set of principles known as "responsible artificial intelligence" (AI). Responsible AI entails considering how AI systems may affect society more broadly and taking the necessary steps to bring these technologies into line with stakeholder values, legal requirements, and ethical standards. The goal of responsible AI is to incorporate these moral precepts into AI workflows and applications to minimize risks and adverse effects while optimizing benefits [40].

The swift integration of Artificial Intelligence (AI) into Business Process Management (BPM) presents previously unheard-of chances for both strategic agility and operational efficiency. These advantages do, however, come with built-in moral, technological, and societal issues that necessitate a methodical and accountable approach to AI implementation. In this regard, Kazakhstan's digital transformation efforts can be guided by a thorough framework provided by IBM's five core pillars of responsible AI: explainability, fairness, robustness, transparency, and privacy.

Building trust with human stakeholders who depend on AI-driven decisions requires explainability. Businesses can improve decision understanding and support ongoing learning by guaranteeing prediction accuracy and permitting traceability across the data lifecycle. This method lessens the "black box" effect that is frequently connected to AI and gives users the ability to examine and verify AI results. The crucial need to reduce bias and advance equity in AI systems is addressed by fairness. Prioritizing representative and varied data collection, incorporating bias-aware algorithms, and utilizing mitigation techniques like resampling are all essential components of Kazakhstan's implementation framework. To prevent discriminatory outcomes, it is equally crucial to include multidisciplinary teams and ethical review boards to supervise AI design and use.

For AI systems to be considered robust, they must be able to tolerate unusual inputs and possible hostile attacks, guaranteeing dependability and minimizing unforeseen consequences. The design of robust AI architectures that can preserve operational integrity in intricate and changing business environments is the focus of this pillar. Explainability is enhanced by transparency, which helps users see and understand how AI works. By freely sharing the advantages and disadvantages of AI applications, transparent AI promotes accountability by empowering users to assess suitability and identify potential biases or mistakes.

Lastly, privacy protects personal information during AI operations while complying with strict legal requirements like the GDPR. Sustaining public confidence and adhering to legal requirements depends on safeguarding private data and protecting AI models from security breaches.

As seen in Figure 3, incorporating these pillars into Kazakhstan's BPM strategy offers a strong, moral basis for the adoption of AI. In addition to reducing the risks connected with AI, this responsible AI framework establishes Kazakhstan as a pioneer in reliable and sustainable digital innovation [41].

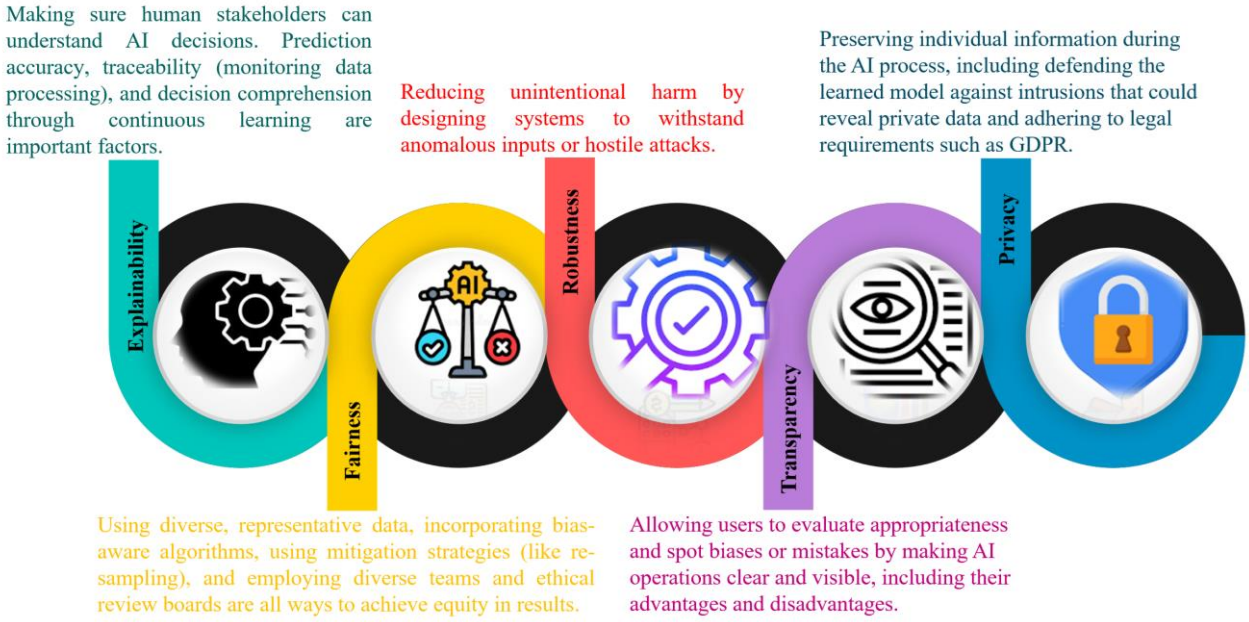

Figure 3. Five Core Elements of Responsible AI: Explainability, Fairness, Robustness, Transparency, and Privacy, along with Important Synopses of Each Elements

IBM has a thorough and organized approach to ethical AI, beginning with the Defining Principles. They stress how crucial it is to set precise moral standards based on their "Pillars of Trust." This fundamental stage guarantees that the development of AI is directed by a clear moral compass and is supervised by a multidisciplinary ethics team that incorporates a range of viewpoints to preserve justice and balance.

Going on to Education & Awareness, IBM emphasizes that moral AI involves people as much as policies. It is essential to teach developers, users, and decision-makers to identify ethical dilemmas, bias, and transparency obstacles. This proactive approach promotes a culture of responsibility around AI and helps avoid issues before they arise.

The necessity of integrating ethics into every step of the AI development process is covered by the third pillar, Lifecycle Integration. IBM promotes ongoing fairness audits and transparent documentation from the very beginning of data collection, model construction, and continuing monitoring. This constant effort guarantees that ethical issues are incorporated into every stage of the AI lifecycle and are not merely an afterthought.

IBM emphasizes the significance of strong governance frameworks that control data usage in terms of implementation. By placing a high priority on informed consent and rigorous adherence to privacy laws, they demonstrate a strong commitment to upholding individual rights and fostering confidence in AI systems by implementing strict privacy safeguards.

Another crucial area is human oversight, where IBM advises clearly defining who is responsible for AI systems. By keeping people informed, AI will continue to be subject to moral principles over time, enabling intervention and correction when necessary. This strikes a balance between automation and the essential human judgment.

Finally, acknowledging that AI ethics are a shared responsibility, IBM promotes external cooperation. Working together with outside specialists, groups, and open-source communities keeps IBM up to date with changing best practices and creates a cooperative atmosphere for addressing new ethical issues collectively.

Building trust through clarity (explainability, transparency), fairness, resilience, privacy, and ethical implementation is covered in detail by AI framework. IBM provides a strong model for the deployment of ethically responsible AI by integrating these principles into organizational structures, training, lifecycle processes, and collaboration.

IBMs suggested six-step method for integrating ethical considerations into the AI lifecycle is depicted in Figure 4. The framework starts with Defining Principles, where a multidisciplinary ethics team supports the establishment of AI ethics under the Pillars of Trust. Stakeholders are guaranteed to be able to identify ethical, biased, and transparent issues through education and awareness. Lifecycle Integration uses open documentation and continuous fairness audits to integrate ethical protection into AI development at every level. Strong governance for data usage, informed consent, and adherence to privacy laws are prioritized during implementation. AI systems are held accountable by human oversight to uphold long-term ethical compliance. To guarantee alignment with changing best practices, External Cooperation also encourages cooperation with organizations, open-source communities, and industry experts [42].

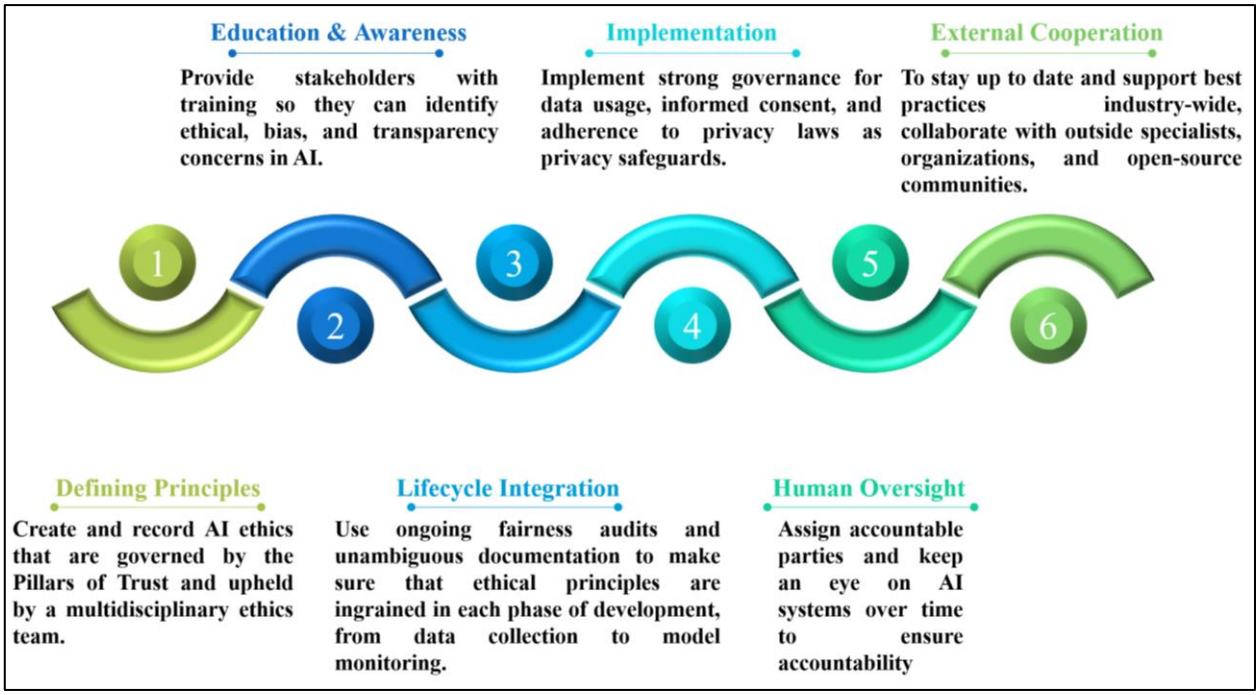

Figure 4. Framework outlining key principles for ethical AI development

3-1- Big Data and AI for Process Driven Business

Big Data and artificial intelligence (AI) are essential to modernizing business process management (BPM) because they provide data-driven decision-making, improved efficiency, and predictive insights. Integrating AI into BPM can greatly enhance organizational performance in Kazakhstan, a country going through a digital transformation. Big Data and AI work together to create a potent feedback loop that allows for deeper insights and more precise predictions by feeding sophisticated AI algorithms with enormous volumes of data. Big Data gives AI systems the raw data they need to find patterns, trends, and anomalies at scale. This data can be anything from structured databases to unstructured social media feeds. By automating data cleaning, classification, and real-time decision-making, artificial intelligence (AI) improves Big Data processing and enables the rapid and effective extraction of valuable knowledge. When combined, they revolutionize industries by fostering more intelligent business plans, individualized interactions, and previously unthinkable creative solutions.

Synergy between AI and Big Data: Big Data and AI have a mutually beneficial relationship:

AI for Big Data: AI tools, such as deep learning, machine learning, and natural language processing, process and examine enormous datasets to find trends, patterns, and anomalies. Businesses can quickly and accurately make well-informed decisions thanks to this capability.

Big Data for AI: The availability of sizable, varied datasets is essential to the performance of AI models. Big Data gives AI systems the volume and diversity of information they need to grow, learn, and adapt over time.

Improving Human Decision-Making through Augmented Intelligence: The focus of augmented intelligence, a branch of artificial intelligence, is on human-AI cooperation. It improves decision-making by fusing machine capabilities with human expertise. This method guarantees that AI enhances human judgment rather than takes the place of it, which is especially advantageous in complex business settings.

AI in Data Analytics: Quickening Understanding: By automating the processing of massive datasets, spotting patterns, and formulating predictions, artificial intelligence (AI) speeds up data analytics. For companies looking to make accurate and timely data-driven decisions, this capability is essential.

3-2- Proposed AI-BPM Implementation Framework for Kazakhstan

The proposed framework for incorporating AI into business process management (BPM) in Kazakhstan is a timely opportunity as well as a strategic necessity. The framework guarantees that AI adoption is based on operational viability and long-term sustainability rather than being haphazard or purely aspirational by organizing the approach around five interconnected pillars: infrastructure development, data governance, skill development, ethical standards, and public-private collaboration [43].

The focus on developing infrastructure is especially justified. Without a robust digital foundation that includes fast connectivity, interoperable platforms, IoT-enabled physical assets, and real-time data collection systems, AI systems are unable to produce quantifiable value [44]. This is exemplified in the Greenlight logistics case: relatively simple but well-integrated technologies like data collection terminals (TSD), digital dashboards, and GPS tracking led to significant performance gains, including a 90% reduction in errors, a 98% on-time delivery rate, and a 20% increase in redemption. These tools establish the operational conditions necessary for the successful layering of AI algorithms later when they are integrated into a scalable and resilient infrastructure. Without this foundation, attempting to apply advanced AI runs the risk of costly underperformance [45].

The framework's dedication to data governance is equally important. The accuracy of AI's decision-making depends on the quality of the data it analyzes. The entire BPM ecosystem is at risk of fragmentation, cyber vulnerability, and a decline in public trust if there are unclear regulations governing data quality, ownership, access rights, and security. The first step in facilitating safe AI interoperability across sectors and geographical areas will be the establishment of national data governance standards that are in line with both local regulatory frameworks and global best practices [46].

Human capital readiness is a common bottleneck in developing digital economies that is addressed by the third pillar, skill development. In addition to engineers and data scientists, operational managers and frontline employees who have been trained to work with and understand AI outputs are also needed for AI-enabled BPM systems. This is demonstrated by Greenlights own experience, which shows that dashboards and TSD investments were only successful because employees were properly trained to use them. Scaling AI adoption outside of urban areas and into regional economies will require a national push for AI literacy, digital tool vocational training, and sector-specific upskilling.

A vital layer of governance is added by ethical standards, which guarantee that the use of AI in BPM upholds accountability, transparency, and equity. This is especially important given Kazakhstan's hybrid public-private service system, where, if unchecked, AI-driven automation may unintentionally replace jobs or introduce biases into decision-making. Establishing ethical standards in advance will help developers and legislators make sure AI promotes just economic growth.

Lastly, the unifying factor that connects the framework is public-private cooperation. The infrastructure, governance, talent, and trust required for responsible AI adoption cannot be provided by any one actor, government, academia, or industry on their own. Innovation can be accelerated while sharing risks and rewards through collaborative platforms, co-funded pilot projects, and shared data ecosystems. As evidenced by Kazakhstan's experience developing corridor-based infrastructure (such as the digitization of Middle Corridor logistics), coordinated, multi-stakeholder investments can result in quick, scalable change.

In conclusion, this framework puts Kazakhstan in a position to benefit from AI's revolutionary potential in BPM without falling victim to the traps of overambition or lack of preparation. It stresses a well-rounded strategy, whereby advanced AI solutions are layered on top of the enabling conditions strong infrastructure, safe and high-quality data, and qualified human capital. A comprehensive implementation could position the nation as a leader in AI-enabled process management in Central Asia and serve as a template for responsible digital transformation in economies with comparable structures.

Figure 5 proposed framework depicts the five interrelated pillars necessary for the ethical incorporation of AI into Business Process Management (BPM) in Kazakhstan's socioeconomic and infrastructure context. To enable AI functionality, the sequence starts with Infrastructure Development, which emphasizes significant investment in reliable digital systems. Data governance uses well-defined policies to guarantee data security, quality, and regulatory compliance. The goal of skill development is to create an AI-literate workforce that can efficiently operate and manage AI-enabled systems [47].

By incorporating accountability, transparency, and equity into AI applications, ethical standards guard against abuse and maintain public confidence. Lastly, through collaboration between governmental entities, academic institutions, and industry stakeholders, public-private collaboration promotes innovation and knowledge exchange. The figure's cyclical structure illustrates how these elements are iterative and reinforce one another, guaranteeing that the use of AI in BPM is sustainable and responsible.

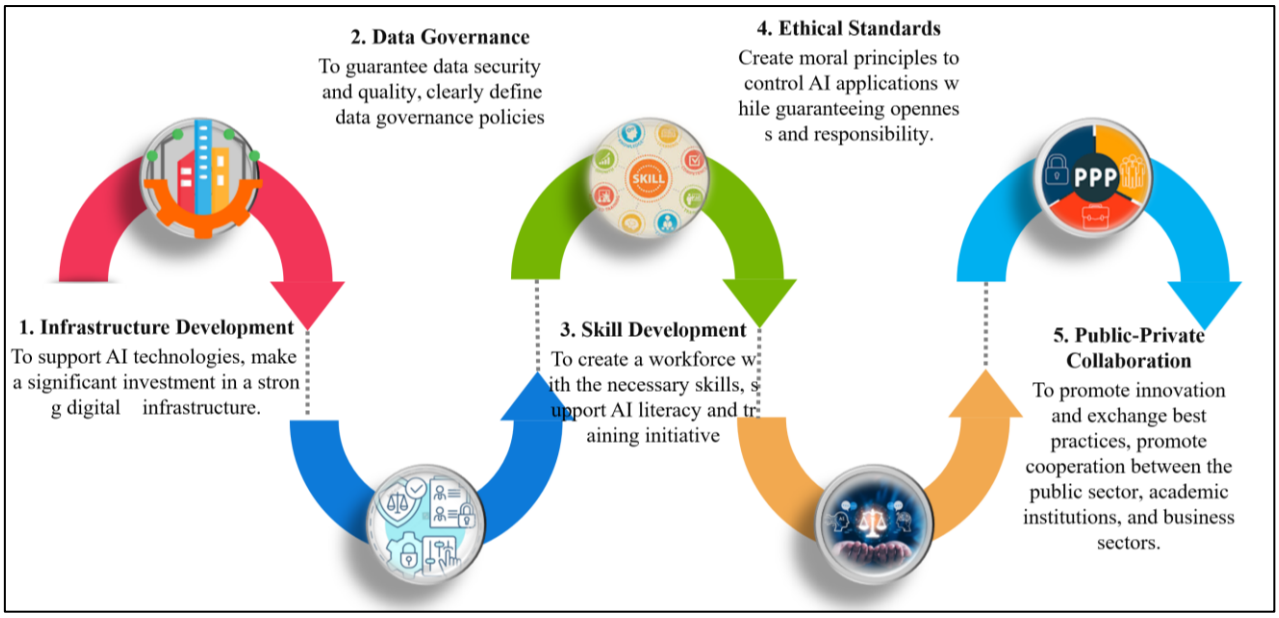

Figure 5. Responsible AI-BPM Implementation Framework for Kazakhstan

3-3- Data Governance and Categorization as a Strategic Facilitator for AI-Powered Business Process Management

With over 5.4 billion internet users worldwide, data has become both a crucial resource and a regulatory challenge in today's data-driven economy, according to the Navigating Data Governance: A Guiding Tool for Regulators framework. Strong data governance is not only a compliance exercise but also a strategic requirement for enabling responsible AI in Business Process Management (BPM) for Kazakhstan, which is aggressively pursuing national AI strategies and growing digital services. With the help of explicit policies, role definitions, and accountability frameworks, the guidelines emphasize that governance should cover the entire data lifecycle, from collection and storage to sharing and disposal. This is in line with Kazakhstan's requirement to integrate cross-border trade systems, Smart City projects, and e-government while maintaining privacy, security, and trust.

Data classification, which methodically divides data into Secret, Confidential, Restricted, or public categories, is a fundamental component of the framework. This would entail, for instance, designating national ID biometric data as Confidential, internal draft policy papers as Restricted, public consultation reports as Public, and critical infrastructure vulnerabilities as Secret in the Kazakh context. By applying uniform access controls, encryption standards, and handling protocols, such structured classification would assist Kazakh regulators and companies in lowering the risk of data breaches and non-compliance with regulations. Importantly, the framework recognizes that different jurisdictions have different classification schemes [48]. To enable legal cross-border data flows, Kazakhstan, which operates in regional trade blocs and aims to increase digital exports, must harmonize its own definitions with those of its important international partners.

The paper also emphasizes the necessity of balanced regulation, which would allow for innovation and cross-border data use while guaranteeing strong privacy and security safeguards. To participate in global value chains for AI-enabled BPM services and draw in foreign investment, Kazakhstan must strike this balance. Although not always applicable, experimental mechanisms such as cooperatives and data sandboxes could be implemented in Kazakhstan to promote public-private cooperation and test AI-based BPM solutions in a controlled setting [49].

Kazakhstan can establish a unified regulatory environment where reliable data governance supports efficient AI implementation in BPM by incorporating these ideas into its new AI and data governance legislation. This would improve citizen confidence in digital services, boost operational efficiency in the public and private sectors, and establish Kazakhstan as a responsible regional leader in AI-enabled process innovation.

An essential component of efficient data governance and a driving force behind evidence-based decision-making is data interoperability, or the capacity to access, process, and exchange data between disparate systems with ease. Interoperability guarantees that datasets are usable across future applications, allowing for deeper insights and enhanced regulatory capabilities when they are incorporated early in data planning and collection [50]. Strong interoperability frameworks foster innovation, improve the delivery of digital services, and support coherent information ecosystems, as demonstrated by programs like the European Union's Digital Single Market. The integration of telecom, government, and industry datasets in the Kazakh context would strengthen oversight and policy formulation by giving regulators a comprehensive view of sectors. But obstacles like redundant, jumbled, or badly formatted data can erode interoperability, resulting in inefficient systems and poorly informed choices [51].

The five themes of the Data Interoperability Maturity Model (DIMM) business, cybersecurity, legal, semantic, and technical are shown in Figure 6. The model offers an organized framework for evaluating how well businesses can use, share, and integrate data across systems and processes. DIMM emphasizes the interaction between operational capacity (business), secure infrastructures (cybersecurity), legal compliance procedures, semantic standardization, and enabling technologies (technical) in the context of Kazakhstan's corporate environment. Businesses can find gaps and make targeted improvements, such as standardizing metadata, integrating secure APIs, and establishing clear regulatory agreements, by assessing their maturity levels across these dimensions. Such advancements are necessary to create a robust AI-enabled BPM ecosystem, where interoperability fosters transparency, regulatory agility, and public trust in digital transformation projects in addition to increasing efficiency and innovation [52].

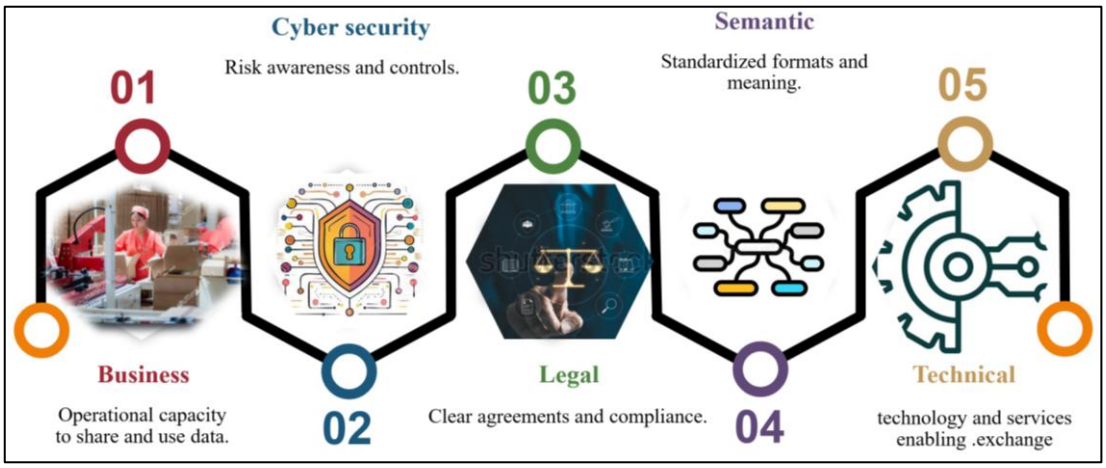

Figure 6. Five themes of the Data Interoperability Maturity Model (DIMM) for enhancing data sharing and AI-enabled BPM in Kazakhstan

3-4- Data Governance in the Public Sector Framework for AI-Enabled BPM

A data governance framework specifically designed for the public sector is necessary to facilitate Kazakhstan's responsible adoption of AI in business process management. The framework's three main layers are strategic, tactical, and delivery ensures thorough coverage of technical, organizational, and policy aspects. Figure 7 presents the Public Sector Data Governance Framework, which is designed to guide the responsible adoption of AI-enabled Business Process Management in Kazakhstan. The framework is organized into three interrelated layers:

The Strategic: This layer places a strong emphasis on vision and leadership. It covers topics such as the function of chief data officers, the creation of policies, and the setting of long-term goals and benchmarks. Transparency, accountability, and security are ingrained while ensuring alignment with national initiatives like Digital Kazakhstan.

Tactical Layer: At this level, the ability to implement policies coherently and regulate operationalizes governance mechanisms. This entails setting up stewardship positions and data committees, offering training, making sure there is enough money, and releasing policies and procedures for interoperability, publication, and data sharing.

Delivery Layer: Using data value cycle management, data infrastructure, and data architecture, the last layer concentrates on execution. This entails putting in place procedures and tools for data validation, sharing, and reuse; utilizing technology solutions like federated systems, data lakes, and APIs; and creating a strong architecture that guarantees data integrity, semantic clarity, and interoperability.

When combined, these layers offer a thorough method of data governance for the public sector that addresses organizational, policy, and technical aspects. By utilizing this framework, Kazakhstan can ensure that data assets are utilized for both social and economic benefit, improve regulatory agility, and increase institutional preparedness for AI-enabled BPM.

4- Kazakhstan's National AI Readiness Priorities and AI-Enabled BPM Integration

Kazakhstan has made great efforts to create a robust AI ecosystem in recognition of the technology’s significance. The Concept for AI Development (2024–2029) was unveiled by the government in 2024, with an emphasis on critical infrastructure investment, innovation promotion, and industry-wide AI integration. The creation of a national AI platform, data processing facilities, and a supercomputer are important projects aimed at accelerating the development of AI [53].

A draft AI law has been proposed to guarantee the controlled and responsible development of AI. The purpose of this legislation is to establish classification schemes, regulatory frameworks, ethical standards, and state support measures. The goal of these initiatives is to reduce risks while fostering a balanced environment where AI can flourish. In May 2024, the government formed the Artificial Intelligence and Innovation Development Committee under the Ministry of

Digital Development, Innovation, and Aerospace Industry to direct AI policy and guarantee a coordinated approach. This committee is essential to the development of Kazakhstan's AI strategy, the establishment of legal and regulatory frameworks, and the promotion of AI-related projects in various industries [54]. In Kazakhstan, Klynveld Peat Marwick Goerdeler (KPMG) actively supports these initiatives by working with important stakeholders to encourage the advancement and uptake of AI throughout the nation.

Given the urgency of the AI transformation, KPMG carried out this survey to evaluate Kazakhstani companies' readiness for the change. Over the course of two months, the study collected data from over fifty businesses in a variety of industries. KPMG discovered important trends, obstacles, and opportunities influencing AI adoption by assessing businesses according to their level of AI readiness [55, 56].

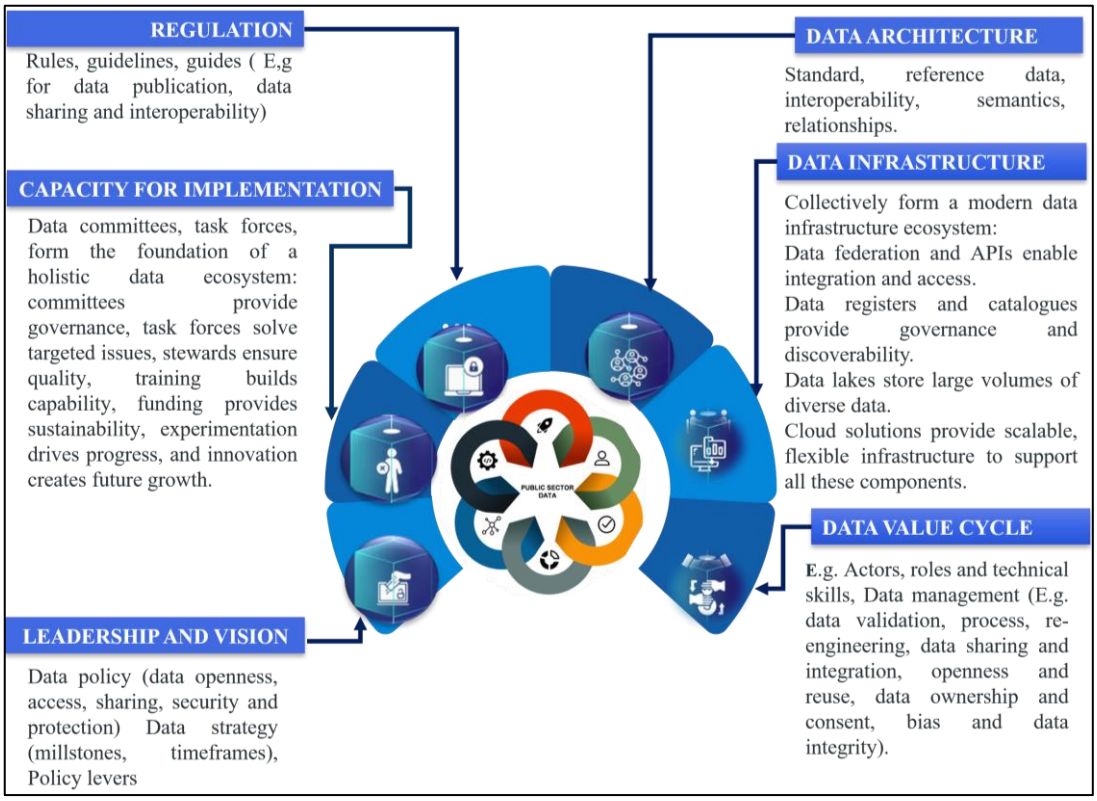

Figure 7. A proposed public sector data governance framework with a strategic, tactical, and delivery layer structure for ethical AI-enabled business process management in Kazakhstan

Businesses, industry leaders, and policymakers can use the report's findings as a resource. By disseminating these insights, we hope to assist organizations in assessing their level of AI readiness, overcoming obstacles, and advancing Kazakhstan's AI-driven future.

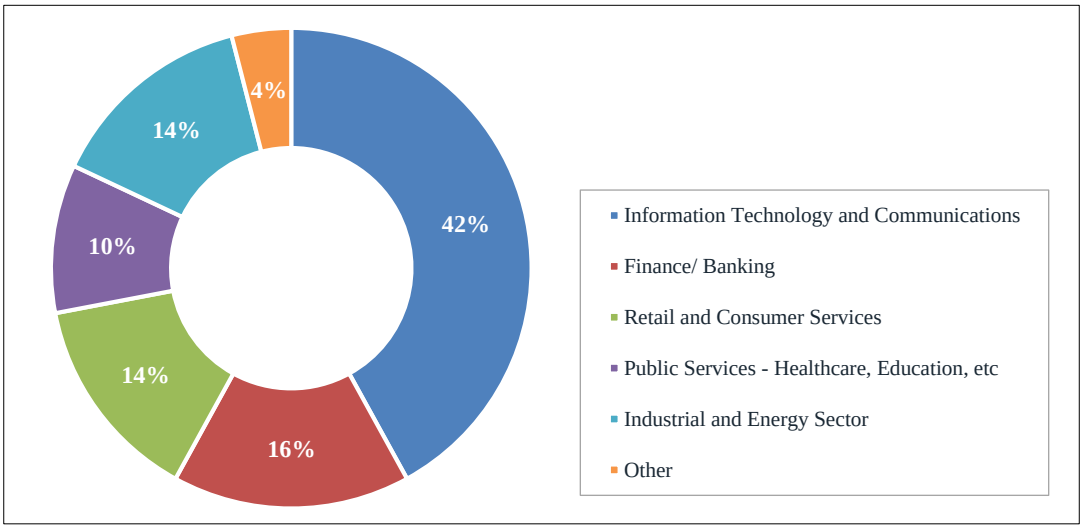

Figure 8. AI readiness by industry, including IT, finance, retail, public services, and industry [57]

More than 50 businesses from a variety of industries, including IT and communication, finance, retail and consumer services, public services, and the industrial and energy sectors, participated in the AI Readiness Survey. 36% of respondents reported annual revenue under USD 1 million, 25% in the USD 1–10 million range, 16% in the USD 10–100 million range, and 23% over USD 100 million. This ensured a comprehensive perspective by including participants from a range of sizes and financial scales [58]. Despite the survey's focus on Kazakhstani businesses, many of them have operations locally, regionally (in Central Asia), or internationally, offering a more comprehensive view of AI readiness.

The disparities in AI readiness among Kazakhstan's major industries are shown in Figure 8. The IT industry is the most prepared, as might be expected given its robust digital infrastructure, highly qualified workforce, and enthusiastic embrace of cutting-edge technologies. Due to early AI experiments in banking, fintech, and risk management, the financial sector closely follows [59]. Although adoption varies between large and small businesses, retail exhibits a moderate level of readiness with increasing investments in supply chain optimization, customer analytics, and e-commerce platforms. Lower preparedness in public services highlights the possibilities and difficulties of incorporating AI into governance, healthcare, and education, where advancement is still constrained by regulatory frameworks and financial limitations [60, 61].

4-1- Kazakhstan's Use of AI in Sectoral Leadership and Business Process Management

KPMG asked respondents at the beginning of the survey if their companies had a specific AI transformation strategy [31]. This first question was intended to assess the degree of progress in AI adoption, both in terms of the existence of such a strategy and its current stage of execution. The answers showed a range of maturity, from early-stage research to fully functional AI strategies. Interestingly, no organization said it had any plans to adopt AI, demonstrating how widely AI's value is acknowledged across industries.

Companies were divided into three groups to better represent these variations. Organizations in the first group, referred to as Leaders, had either a fully functional AI strategy or a well-defined plan that was already backed by use cases that had been put into practice. Businesses with AI strategies still in pilot testing or actively developing were included in the second category, Explorers. Lastly, Beginners represented businesses without a defined strategy that were just beginning to explore the adoption of AI [62].

According to the findings, about one-third of businesses fit the description of AI leaders. Only 8% of respondents said they had a fully functional AI strategy, indicating that most businesses are still moving toward a more thorough integration of AI into their operations. Adoption levels were found to be significantly influenced by industry sector and organizational size. About half of larger businesses were categorized as leaders, a much higher percentage than that of smaller businesses (less than one-third). With 63% of businesses identifying as leaders, the financial sector was by far the most prominent. On the other hand, the IT and telecommunications industry, which is dominated by startups and younger businesses, had a high percentage of explorers but few leaders, indicating a strong culture of experimenting with AI technologies [61] .

The survey also looked at organizational levels of AI awareness and engagement in addition to adoption stages. The results show a high baseline of familiarity: 52% of respondents said they were very familiar with and actively involved in AI-related decision-making, compared to 30% who said they were moderately familiar but not directly involved. Just 18% of respondents said they were aware of AI but did not participate in strategic conversations. Higher levels of direct engagement were shown by larger companies, especially those with more than 500 workers; these were frequently associated with organized leadership and focused innovation initiatives. On the other hand, despite being aware of AI's potential, smaller businesses tended to show lower levels of direct involvement.

When considered collectively, these findings show that although Kazakhstani organizations acknowledge the value of AI in business process management, adoption maturity is still uneven. While startups and smaller businesses are still in the exploratory stage, larger corporations and the financial sector are setting the pace.

By promoting knowledge transfer from larger corporations and the financial sector where AI maturity is most advanced to smaller businesses and startups that are still in the exploratory stages, Kazakhstan can continue to promote sector-wide AI adoption, according to the findings [62]. Specific measures like government-backed pilot programs, industry-led mentorship, and cross-sector partnerships could hasten the integration of AI and close the maturity gap. Kazakhstan can create a more balanced ecosystem where AI promotes efficiency, competitiveness, and innovation across a range of industries by raising awareness and encouraging practical engagement among smaller organizations. This will guarantee that advancements in business process management have a positive impact on the overall economy.

Figure 9 shows the differences in AI adoption by industry and organizational size, indicating that while smaller businesses and industries like IT and communications have higher percentages of exploratory or beginner-level adoption, larger corporations and the financial sector are more likely to be AI leaders. It draws attention to how differently AI integration has advanced in various business contexts [63].

4-2- Kazakhstan's Measures to Fortify the Groundwork for AI Adoption

Data infrastructure, skilled human capital, and a well-thought-out regulatory framework are the three fundamental pillars of a strong national AI strategy, which demands more than just lofty goals. Businesses in Kazakhstan are becoming more aware of AI's revolutionary potential. However, there are still barriers to broad adoption, especially when it comes to creating data ecosystems that are ready for AI, developing specialized knowledge, and negotiating changing governance frameworks. The research encouraging findings show that the groundwork for long-term AI integration is being progressively strengthened by investments in workforce training, infrastructure, and regulatory awareness.

One of the biggest obstacles to the adoption of AI is the data infrastructure, which is deemed either insufficient or in need of major improvement by half of Kazakhstani businesses, according to KPMG report [31]. Even though 56% of the market's AI leaders report using sophisticated systems like data warehouses and data lakes, many businesses still rely on simple databases and enterprise resource planning (ERP) platforms. However, only 42% of "explorers" and 20% of "beginners" use advanced infrastructures, highlighting a gap between data readiness and adoption maturity.

Evidence points to a changing mentality despite these gaps. Data infrastructure is becoming increasingly important to businesses at all stages of AI adoption. Infrastructure is the second highest investment priority among beginners and the top priority among explorers, indicating an understanding that scalable AI deployment is impossible without strong data systems. In contrast, leaders take a more balanced approach, allocating funds for training, research, and development in addition to infrastructure, which reflects a top-down, structured approach to AI readiness.

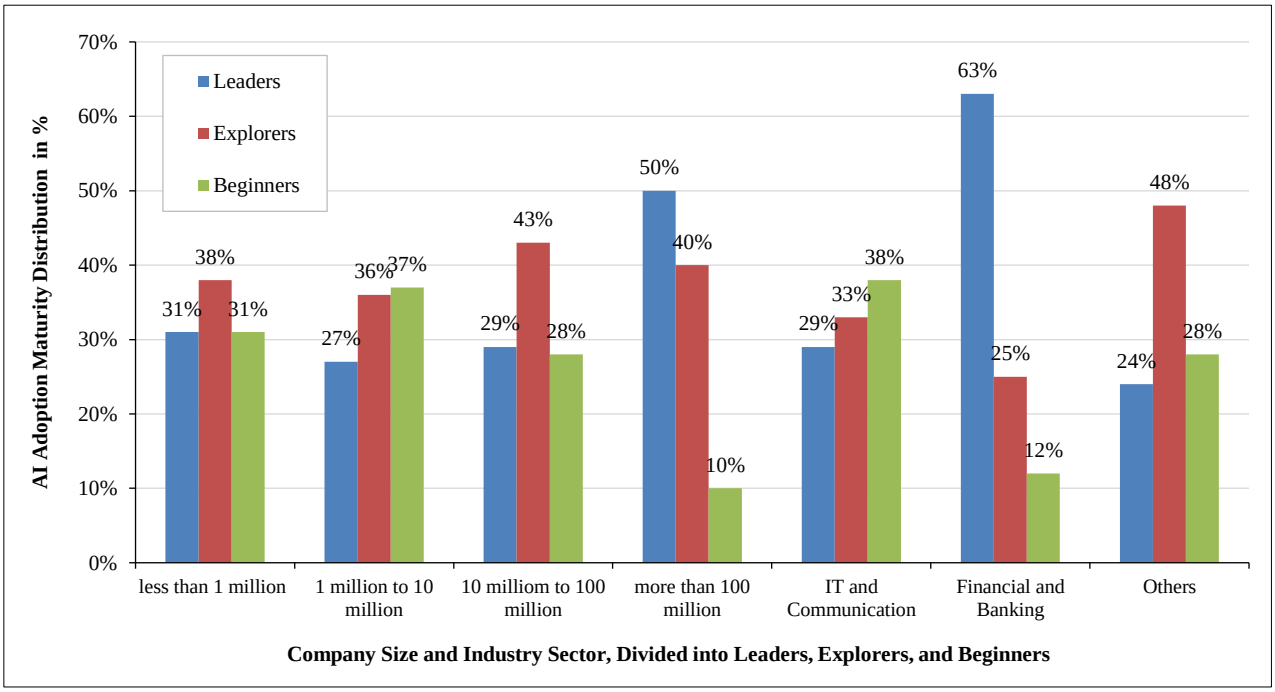

Figure 9. Kazakhstan's AI Adoption Maturity Distribution by Company Size and Industry Sector, Divided into Leaders, Explorers, and Beginners

The picture of the talent landscape is not entirely clear. Kazakhstan's strong technical foundation and expanding expertise are reflected in the moderate to high levels of AI proficiency reported by 60% of surveyed companies by KPMG report [31]. The migration of highly qualified workers from nearby nations like Belarus, Ukraine, and Russia has improved workforce preparedness and further expanded the domestic AI labor market.

However, there are still important gaps. Due to a lack of internal expertise, nearly one-quarter (24%) of businesses rely on outside consultants for AI-related projects. Furthermore, one of the most mentioned obstacles to adoption is still the lack of internal AI experts. Only 62% of companies have formal training initiatives in place, and 22% have no specific plans to strengthen internal AI competencies, despite 78% of firms reporting intentions to upskill their employees. This discrepancy between ambition and reality raises the possibility that businesses will continue to rely on outside knowledge or encounter difficulties when attempting to scale sophisticated AI applications if they do not make systematic training investments.

The distribution of organizational approaches to data governance and artificial intelligence in Kazakhstan is shown in Table 1. The results show that most businesses (40%) currently use general data policies instead of frameworks tailored to AI, indicating a low level of governance maturity. A sizable percentage of businesses (22%) say they don't

have a formal data policy in place, which raises concerns about ethical oversight, accountability, and compliance. A growing understanding of the significance of structured governance is indicated by 18% of organizations that say they intend to implement AI policies. Just 10% of businesses have AI-specific policies in place, and another 10% admit that they have some policies in place but need to be improved. Together, these findings imply that although awareness of AI governance is growing, most organizations are still in the transitional phase and that there is significant room to improve policy frameworks to encourage the adoption of AI in a responsible and sustainable manner.

Table 1. Distribution of Organizational Approaches to AI and Data Governance Policies in Kazakhstan

AI policies adaptation	Percentage
Adhere to general data policies	40%
Do not follow any data policy	22%
Plan to implement AI policies	18%
AI Policy in place	10%
Partial AI Policy needs improvement	10%

Kazakhstan's AI regulatory environment is still developing. 42% of companies only use general data governance measures, and only 20% say they have AI-specific policies in place. More than 60% of AI leaders, even, do not have regulations specifically designed for AI, highlighting the fact that organizational AI strategies still do not include regulatory compliance as a key component.

The most urgent regulatory concern, according to businesses, is data privacy and protection (40%), followed by ethical considerations (24%), and policy ambiguity (22%). These results are consistent with larger international discussions on responsible AI governance, especially those pertaining to accountability, transparency, and fairness. More focus on ethical supervision and legal clarity will be essential as Kazakhstan develops its AI ecosystem in order to build confidence and guarantee adherence to global best practices.

When combined, Kazakhstan's adoption of AI shows both growth opportunities and challenges. Businesses are moving away from discrete AI use cases and toward all-encompassing approaches that prioritize infrastructure, compliance, and training. The foundation for AI adoption is still being built, though, as evidenced by the unequal distribution of sophisticated data systems, ongoing skills shortages, and inadequate regulatory frameworks. For Kazakhstan to move from awareness to long-term, competitive AI integration, ongoing investment in these three pillars will be crucial.

In terms of AI readiness, the Caucasus and Central Asia (CCA) region exhibits both noteworthy prospects and noteworthy obstacles. The majority of CCA nations lag behind developed and even other emerging markets, according to the IMF's AI Preparedness Index (2024), because of their inadequate digital infrastructure, stringent data localization regulations, scarce human resources, and disjointed innovation ecosystems.

Through productivity improvements, job augmentation, and re-employment effects, generative AI may contribute 2% of regional GDP in the next ten years, and 4% in a leapfrog scenario if adoption picks up speed in line with advanced developing markets. To achieve this, however, certain policy measures are needed, such as increasing cloud and internet infrastructure, making sure that laws are balanced and proportionate, encouraging AI research and public-private innovation, and funding lifelong learning and worker upskills. The region runs the risk of missing this revolutionary wave of AI-driven growth if connectivity, governance frameworks, and talent development don't significantly improve [64].

Kazakhstan is the most notable benefit of the adoption of generative AI among the nations in the Caucasus and Central Asia (CCA) area. Its estimated yearly GDP contribution of USD 5.5 billion places it far ahead of its regional counterparts. Although the GDP of the four countries under consideration—Kazakhstan, Georgia, Azerbaijan, and Armenia—is expected to increase by 2% over the next ten years, Kazakhstan is positioned as a regional leader because to its sizable economy and higher percentage of occupations subject to augmentation.

Kazakhstan could use AI as a catalyst for creativity and productivity, as evidenced by the fact that generative AI is predicted to complement about 54% of occupations there, the greatest percentage of any country under study. Furthermore, even though 5% of employment is expected to be partially or completely replaced by automation, the nation's readiness to adopt this technology suggests a more dynamic and revolutionary labor market that can rehire workers in new AI-enabled opportunities.

In this regard, Kazakhstan is not only the largest economy in the CCA but also the one that is best equipped to turn generative AI into real economic and societal benefits. Kazakhstan may establish the standard for AI-powered growth in the area and open the door to increased competitiveness and innovation-driven prosperity by making strategic investments in connectivity, skill development, and supportive policies.

The expected GDP contributions and workforce changes brought about by the deployment of generative AI are displayed in Table 2. In addition to reflecting the larger regional opportunities and challenges in labor market adaption, it highlights Kazakhstan's leadership in optimizing AI's economic potential.

Table 2. Projected Economic and Employment Impacts of Generative AI in Selected CCA Countries (10-Year Horizon)

Country	GDP Contribution (USD bn)	GDP Impact (%)	Jobs Complemented (%)	No Automation (%)	Partially/Fully Displaced (%)
Armenia [57]	0.5	2%	46%	50%	4%
Azerbaijan [64]	1.3	2%	38%	59%	3%
Georgia [65, 66]	0.6	2%	49%	47%	4%
Kazakhstan [67]	5.5	2%	54%	41%	5%

4-3- Lessons from Early Success and Ongoing Difficulties in Scaling AI for Actual Business Impact in Kazakhstan

AI has a lot of promises, and businesses from a variety of sectors are hopeful that it will change almost every facet of operations. There is so much faith in AI that not a single business in Kazakhstan voiced doubts about its potential. Nevertheless, many organizations are having difficulty turning potential into quantifiable value despite this zeal. Even though 58% of businesses report early success, the results vary; some see major breakthroughs, while others only see slight improvements, and many are still stuck in pilot projects that haven't produced tangible results. The gap between leaders in AI and those in their infancy is most noticeable. The gap between leaders in AI and those in their infancy is most noticeable. The biggest benefits are being felt by leaders who have incorporated AI more thoroughly into their business processes; most are reporting significant gains, and all are reporting improvements. Explorers and novices, on the other hand, experience slower progress, and almost half acknowledge they have not seen any discernible impact.

Table 3. Kazakhstan's Anticipated Benefits of AI Adoption in All Business Functions

AI Expectation	Percentage
An improvement in operational effectiveness	75%
Better judgment	74%
An advantage in the marketplace	60%
Improved experience for customers	56%
Lower expenses and higher profitability	54%

The expected advantages of implementing AI across business functions in Kazakhstan are shown in Table 3. An increase in operational effectiveness is the most stated expectation (75%), highlighting the widespread conviction that AI will improve efficiency and optimize internal procedures. The expectation of improved judgment and decision-making comes in second (74%), indicating that businesses value AI's analytical powers for operational and strategic decisions. Significant expected outcomes include enhanced customer experience (56%) and competitive advantage (60%) as well, demonstrating the understanding of AI's potential to improve stakeholder relations and external positioning. Finally, while acknowledged, cost reduction and profitability gains (54%) rank lowest among the benefits, suggesting that when Kazakhstani businesses consider integrating AI, they may place a higher priority on qualitative enhancements than just financial results.

Finding the appropriate use cases is the single largest obstacle preventing businesses from progressing. Even half of AI leaders, despite their relative success, struggle to determine where and how to apply AI most effectively, and 64% of organizations still find this to be the most challenging challenge. This implies that passion is insufficient on its own; in the absence of a methodical strategy, investments run the risk of being directed toward areas that do not truly meet business needs. Organizations at varying stages of adoption face distinct challenges, which exacerbate the problem. After overcoming those obstacles, leaders struggle to improve their tactics and guarantee data quality at scale, while novices

and explorers frequently lack the clean, usable data and internal knowledge required to scale AI. What becomes evident is a distinct pattern: advancements in AI adoption do not remove obstacles; rather, they refocus them, highlighting the necessity of an organization-wide approach that changes with time.

The main barriers to Kazakhstan's adoption of AI are shown in Table 4. Finding appropriate use cases for AI is the most urgent challenge, according to 64% of respondents, indicating that many organizations are still unsure of the best way to incorporate AI into their operations. This problem is made worse by a 50% lack of knowledge and experience, underscoring the necessity of capacity building and specialized training. Data-related issues (42%) are also noteworthy, suggesting enduring worries about infrastructure, accessibility, and data quality. Only 28% of respondents cite unclear return on investment as a barrier, suggesting that financial considerations are less important. Similarly, limited executive support (14%) and regulatory and compliance constraints (16%) are recognized but regarded as relatively minor. Overall, these results imply that knowledge gaps and practical implementation, rather than financial or regulatory factors, are the main causes of Kazakhstan's AI adoption barriers.

Table 4. Principal Obstacles to Kazakhstan's AI Adoption

AI Expectation	Percentage
Finding use cases for AI	64%
Insufficient knowledge of AI	50%
Data issues	42%
Unclear return on investment	28%
Barriers to compliance and regulations	16%
Executive support is scarce.	14%
Lack of leaders' ownership of and commitment to AI	27%
Lack of technological infrastructure to support AI	25%
Under resourcing for AI in line organization	21%
Limited usefulness of data	20%
Personal judgment overrides AI-based decision making	19%
Limited relevance of insights from AI	18%
Lack of changes to frontline processes after AI's adoption	12%

Nevertheless, businesses are still committed to growing AI projects. Many are getting ready to adopt more sophisticated technologies, and two-thirds intend to expand AI into new business domains. This goal reflects the strong conviction that AI is a long-term source of competitive advantage rather than merely a tool. But the way forward calls for self-control. Organizations must improve their capacity to recognize high-value use cases, bolster internal knowledge, and guarantee access to trustworthy, high-quality data if they hope to transform their aspirations into tangible effects. The potential of AI is undeniable, but only those who approach it with clarity, structure, and a business-wide strategy will be able to fully realize its transformative potential.

5- Ways to Succeed with AI in Kazakhstan's Business Environment

By combining AI-enabled BPM with Kazakhstan's AI readiness priorities, digital transformation is guaranteed to promote social responsibility and economic competitiveness. Kazakhstan can increase manufacturing, logistics, energy, and financial productivity while adhering to responsible AI adoption principles by coordinating process automation with national policy objectives [68, 69]. Because of this alignment, Kazakhstan is positioned to lead the region in responsible, AI-driven business process innovation in addition to being a consumer of global AI solutions.

More than just a technical advancement, integrating AI into Kazakhstan's business environment is a strategic journey that calls for foresight, tenacity, and meticulous planning. Research indicates that even though the path may appear difficult, the benefits economic growth, efficiency, and operational excellence make the effort well worth it. Effective use of infrastructure and data is the first step in building a solid foundation. AI projects cannot grow or produce significant outcomes without solid systems and trustworthy data. Comprehending and interacting with AI regulations is equally crucial. Being proactive in this area enables businesses to innovate responsibly, uphold compliance, and cultivate stakeholder trust, all of which contribute to sustainable progress.

Using a top-down AI approach is essential since leadership is essential. Organizations can find high-value use cases and guarantee maximum impact across operations when executives promote alignment and incorporate AI into the larger business plan. Another essential component is talent. Although Kazakhstan has many talented workers, success hinges on carefully selecting, developing, and upskilling the appropriate personnel to carry out the AI vision. Lastly, investment is important. Allocating resources boldly and strategically is necessary to scale AI beyond early trials. Businesses can unlock transformative potential, increase returns on investment, and gain a sustainable competitive advantage by making the proper level of commitment to AI. When combined, these actions provide a road map for businesses looking to fully utilize AI and build a future where innovation and expansion coexist.

Figure 10 shows how to apply AI in organizations in a step-by-step, cyclical manner. Every numbered step emphasizes a crucial component of success: Step 1 involves utilizing data and infrastructure to establish a solid foundation, and Step 2 involves elucidating and disseminating AI regulations to guarantee responsible innovation. The model highlights the significance of a leadership-led, top-down AI strategy (Step 3), along with focused talent investments and upskill to build AI expertise (Step 4). Lastly, it emphasizes how important it is to invest heavily in AI to scale projects and gain a sustained competitive edge (Step 5). The arrows that link the steps imply an ongoing, iterative process in which every component supports the others, assisting businesses in integrating AI successfully and achieving long-term business benefits [70].

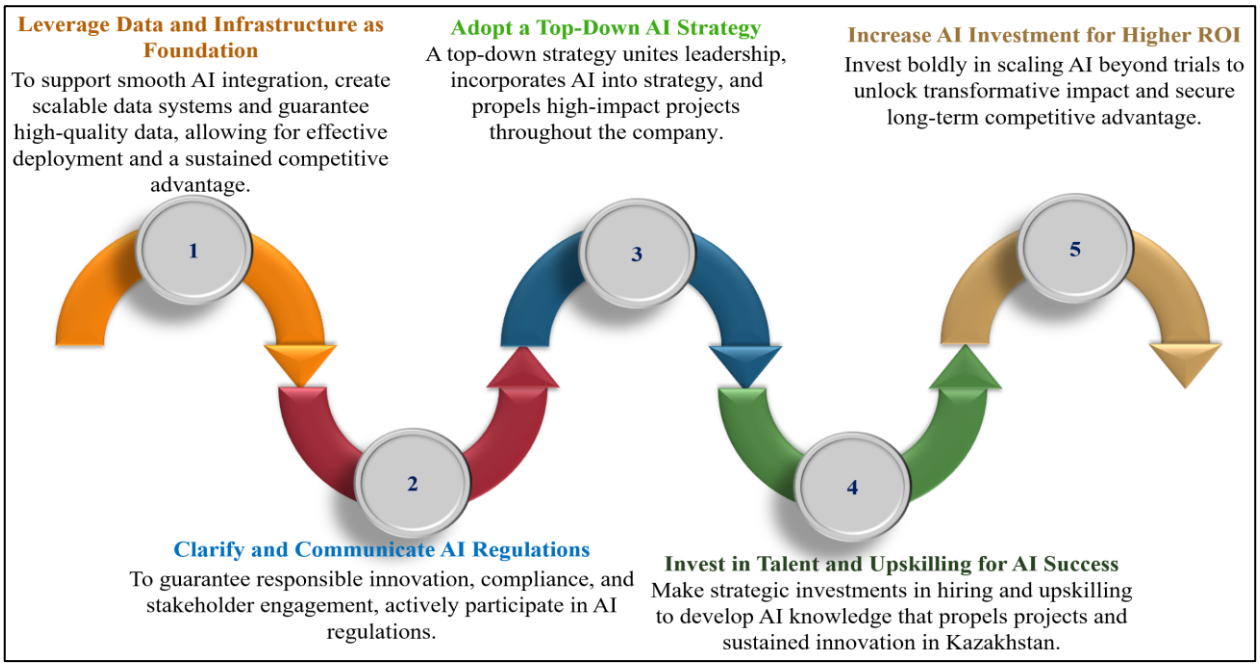

Figure 10. Five-Step Framework for Businesses in Kazakhstan to Strategically Integrate AI

5-1- Investment Targeting and Timing Powered by AI

In today's global economy, artificial intelligence is quickly emerging as the key factor defining change, disruption, and competitive advantage [71]. AI is already changing how companies compete across borders and industries, opening new sources of efficiency, and spurring innovation on a never-before-seen scale. With aspirations to modernize and diversify its economy, Kazakhstan is at a turning point in its history where the adoption of AI could spur growth and establish the nation as a leader in digital innovation in the region.

Based on the results of our AI Impact Index, we examine not only how quickly these changes are occurring but also which industries in Kazakhstan and around the world offer the biggest potential for growth. Businesses can clearly see where the opportunities are, what threats to expect, and how to best position themselves for success thanks to our research, which delves into the implications of AI sector-by-sector and product-by-product.

The Index offers a special gauge of AI's capacity to improve quality, save time, and offer more customization in goods and services. Based on this analysis, we have created nearly 300 use cases that illustrate the area's most likely to see innovation, the factors driving adoption, the dates for market readiness, and the potential roadblock as well as solutions.

Table 5 offers a useful benchmark for predicting the future direction of Kazakhstan's economy, even though it represents global projections for AI adoption maturity. More than 40% of financial services and more than half of retail have already adopted AI, indicating a rapid near-term adoption in consumer-driven industries like these. This is in line with current trends in fintech development, digital payments, and e-commerce growth, all of which are being driven by regional banks and startups and could put Kazakhstan at the forefront of adoption in the region.

Table 5. Global AI Adoption Maturity by Sector: Consequences and Future Directions for the Kazakh Economy

Sector	Near term (0-3 yr)	Mid-term (3-7 yr)	Long term (7+ yr)
Healthcare	37%	23%	40%
Automotive	35%	47%	18%
Financial Services	41%	59%	0%
Transportation and Logistics	41%	41%	17%
Technology, Communications and Entertainment	47%	36%	17%
Retail	54%	38%	8%
Energy	39%	44%	17%
Manufacturing	14%	83%	3%

However, the healthcare industry shows a more complicated trajectory, with 40% of AI adoption postponed to the long term and 37% anticipated in the near term. This is in line with Kazakhstan's own healthcare modernization initiative, where AI applications such as telemedicine and diagnostic support are just starting to take shape but will need infrastructure investment and talent development to mature.

The table indicates a sizable mid-term adoption window for energy, logistics, and transportation. These industries are especially important to Kazakhstan because of its geopolitical position as a transit hub for Eurasia and its reliance on mining, oil, and gas. As a result, AI-enabled optimization, predictive maintenance, and efficiency enhancements could have a significant positive impact. Kazakhstan could address domestic issues like resource dependency and infrastructure bottlenecks while simultaneously adjusting to changes in the world.

Global estimates for the manufacturing sector indicate a slower start but a massive mid-term surge, with 83% adoption anticipated in three to seven years. AI may hasten Kazakhstan's transition to advanced manufacturing, where industrial diversification is a key component of economic policy. This will, however, require investments in automation, smart technology, and workforce upskilling—areas in which Kazakhstan currently lags top economies.

The bigger picture is obvious: Kazakhstan can outpace other countries in mid-term opportunities, especially in manufacturing, logistics, and energy, even though it might not adopt AI as quickly as more developed nations soon. Prioritizing infrastructure, developing AI talent, and offering incentives to companies to implement and expand AI solutions are crucial.

5-2- The Use of Artificial Intelligence to Promote Economic Development in Central Asia

Eight countries at different levels of development make up Central Asia, which is becoming a dynamic region with economic promise. Despite the steady progress of Armenia (GDP: USD 24.1 billion) [72], Azerbaijan (USD 72.4 billion) [73], Georgia (USD 31 billion) [74], Kyrgyz Republic (USD 17.5 billion) [75], Tajikistan (USD 12 billion) [76], Turkmenistan (USD 64.24 billion) [77], and Uzbekistan (USD 115 billion) [78], Kazakhstan is the region's largest country with a GDP of USD 296.74 billion and a population of almost 20.59 million [79]. Its geographical location, wealth of natural resources, and aggressive reform program make it the economic hub of Central Asia.

The region's sustainable development can be accelerated through the use of artificial intelligence (AI), particularly with the recent advances in generative AI. AI is a disruptive facilitator that can boost competitiveness, productivity, and innovation. It is more than just a technical instrument. AI can support vital sectors like energy, logistics, agriculture, and healthcare for nations like Kazakhstan. It may also act as a driver for diversification away from hydrocarbons.

AI is widely acknowledged as a versatile technology that has the ability to increase productivity on par with the internet or electricity. These possibilities are expanded by generative AI, which gained popularity in 2022 and facilitates new business models, innovation, and the automation of knowledge-intensive tasks. AI can promote inclusive growth and societal advantages in Central Asia, where structural reforms are happening and demographic rewards can be capitalized on. For example, AI-driven logistics and smart infrastructure might revolutionize trade corridors through Georgia and Azerbaijan, while AI-enabled precision agriculture could improve food security in Tajikistan and Uzbekistan.

But there are some inconsistencies in the promise of AI. Its quick spread brings up moral, societal, and financial issues that call for flexible governance. National strategies must be based on responsible AI that is inclusive, trustworthy, and human-centered. Only then will technology be able to help address global issues like sustainable urbanization, fair access to healthcare, and climate change.

Kazakhstan is ideally positioned to spearhead the regional adoption of AI due to its comparatively sophisticated digital infrastructure and investment capability. Kazakhstan can strengthen its position as a leader and collaborator in Central Asia's technology future by establishing itself as a center for AI research, data centers, and regulatory innovation. Adopting AI responsibly and adaptively can greatly expedite the region's path to development. With Kazakhstan as its leader, Central Asia can use AI to bridge growth gaps and create a more creative, safe, and sustainable future for the entire world.

Figure 11 shows the economic and demographic size of eight states in Central Asia. Kazakhstan is the economic leader of the area, with a population of around 20.59 million and the greatest GDP (USD 296.74 billion). With a substantial population of 37.6 million, Uzbekistan exhibits significant potential for growth fueled by its labor force. Tajikistan, the Kyrgyz Republic, and Armenia are examples of smaller economies that demonstrate the region's varied development paths. The statistics together highlight how AI might serve as a catalyst for regional integration and inclusive economic progress [80, 81].

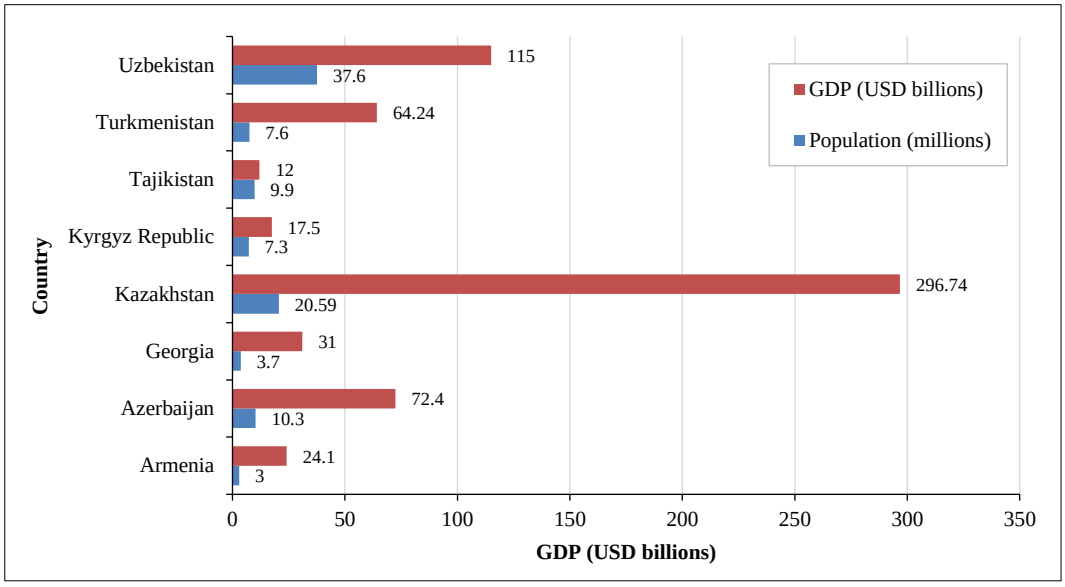

Figure 11. Central Asian countries' GDP and population

5-3-Central Asia and the Caucasus: AI Adoption and Innovation

Countries in Central Asia and the Caucasus lag behind in important drivers of AI adoption and innovation, according to the AI Preparedness Index (2024). For instance, Tajikistan has a total AI Preparedness Index of 37, but only receives 10 points for digital infrastructure and 8 points for ethics and regulations. Likewise, Azerbaijan (47) and Kyrgyz Republic (43) are below the developing market economy benchmark (46). The average advanced economy is 68, and even the comparatively better-performing Georgia (53) and Kazakhstan (55) lag well behind.

- Gap in Digital Infrastructure: Adoption of AI is significantly facilitated by digital infrastructure. With scores significantly lower than those of advanced economies (Tajikistan: 10, Kazakhstan: 35, vs. advanced economies: 60), the majority of the nations in this region have limited access to cloud computing, bandwidth, and computing power. Digital transformation is slowed down and AI implementation at scale is limited by this infrastructural mismatch.
- Ethics and Regulation: Underdeveloped regulations for data governance, AI ethics, and privacy protection are reflected in the similarly low scores for ethics and regulation (Kazakhstan: 20, Tajikistan: 8, compared to advanced economies: 40). Inadequate regulatory frameworks undermine responsible AI development and erode investor confidence.
- Total AI Readiness: The regional lag is shown by the overall AI Preparedness Index. The majority of nations, with the exception of Kazakhstan and Georgia, are below the developing market average, indicating the urgent need for policy and infrastructure development to support AI adoption and innovation.

- A Comparative Perspective: These nations still have a long way to go in terms of catching up to more developed economies. Clear legislative frameworks, AI education, and targeted investments in digital infrastructure could all aid in closing the gap. As AI propels global productivity and economic growth, the region runs the risk of slipping farther behind without such actions.
- Kazakhstan: Central Asia's Leader in AI Innovation and Adoption: Kazakhstan has distinguished itself from other Central Asian and Caucasian nations by becoming a regional leader in the use and innovation of artificial intelligence (AI). Kazakhstan receives a total score of 55 on the 2024 AI Preparedness Index, which is considerably higher than the developing market average of 46 and its regional peers Tajikistan (37) and Kyrgyz Republic (43) with scores of 35 in digital infrastructure and 20 in governance and ethics. This illustrates Kazakhstan's proactive strategy for developing an ecosystem that is prepared for AI.

Figure 12 illustrates the differences in Central Asia's potential for AI adoption, highlighting Kazakhstan's leadership position and smaller economies' lagging positions.

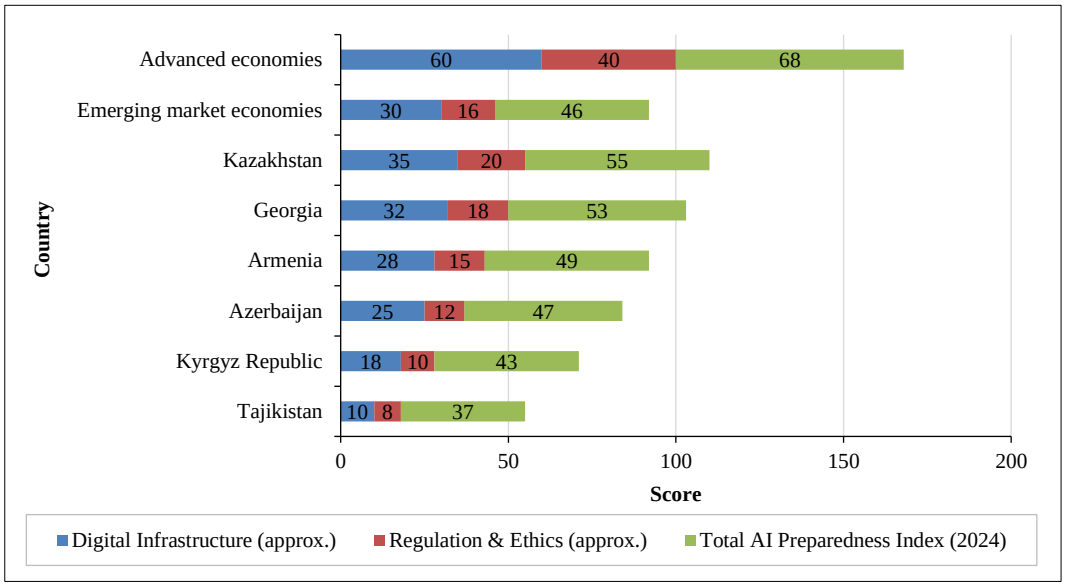

Figure 12. Central Asian Countries' AI Preparedness Index (IMF)

5-4- Generative AI May Add About 2% to the GDP of Armenia, Azerbaijan, Georgia, and Kazakhstan in Ten Years

A game-changing technology, generative artificial intelligence (AI) has the potential to significantly boost Central Asia's economy, especially Kazakhstan's. Generative AI is expected to add around 2% to the GDP of Armenia, Azerbaijan, Georgia, and Kazakhstan over the course of the next ten years. Surprisingly, Kazakhstan has the largest absolute economic benefit, estimated at USD 5.5 billion, while Armenia, Azerbaijan, and Georgia have USD 0.5 billion, USD 1.3 billion, and USD 0.6 billion, respectively.

Both Kazakhstan's broader economy and the sizeable portion of jobs that stand to gain from AI-driven productivity are reflected in the magnitude of the country's possible gains. It is anticipated that generative AI will increase productivity in about 54% of Kazakhstani occupations, the largest percentage in the area, compared to 38% in Azerbaijan. Additionally, a tiny but important portion of jobs (3–5% of all jobs) might see all of their work eliminated, freeing up staff members to concentrate on higher-value work and innovative endeavour's.

The anticipated GDP growth is supported by this mix of reallocation and job complementation. All four countries saw a 2% rise in GDP as a result of the overall productivity enhancement, even if the percentage of impacted jobs varies by country. The similarity in overall productivity increases results from differences in absolute productivity levels; the adoption of AI has a stronger impact in Kazakhstan's more developed sectors because they generate more value per unit of work [81].

Ongoing investments in digital infrastructure, AI education, and regulatory frameworks further solidify Kazakhstan's leadership in this regard. These strategic measures guarantee that the nation will not only be able to profit from generative AI's immediate economic advantages, but also to gain a sustained competitive edge in AI-driven innovation.

In summary, generative AI offers Kazakhstan a game-changing prospect by facilitating the development of high-value commercial ventures as well as broad productivity increases. Kazakhstan has the potential to become a regional leader in AI-driven economic growth by utilizing its size, infrastructure, and labor preparedness, hence establishing standards for its Central Asian neighbour's [57]. The GDP contribution of generative AI and the percentage of jobs that will benefit from productivity improvements in Armenia, Azerbaijan, Georgia, and Kazakhstan during the next 10 years are shown in Figure 13. With the largest percentage of occupations seeing productivity improvements and the highest absolute GDP impact, Kazakhstan stands out.

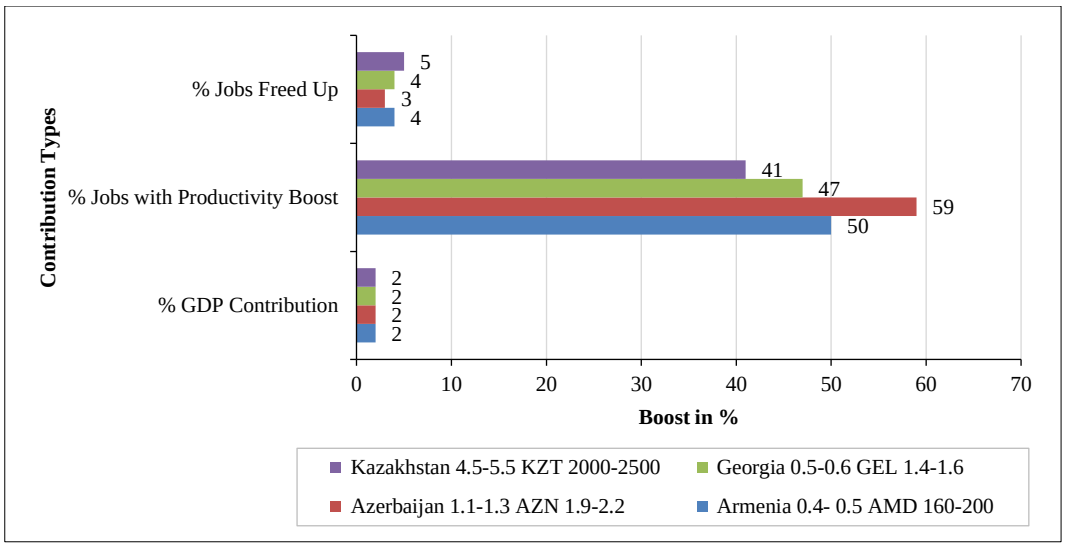

Figure 13. Economic Impact of Generative AI in Central Asia (2024 Projection)

5-5- Central Asian Governments Are Embracing AI Transformation

AI is now seen as a strategic force behind governance and socioeconomic change rather than just a technical tool. Central Asian governments are implementing all-encompassing AI plans to boost public sector productivity and hasten digital modernization. The National Centre for Artificial Intelligence, for example, was established by the Kazakh government and is expected to open in 2025. The center will act as a focal point for incorporating AI into vital public functions, with a focus on immigration, education, and natural catastrophe monitoring. The government's emphasis on societal resilience and human capital development is reflected in these domains.

A major turning point in the region's digital policy environment has also been reached with the announcement of Uzbekistan's full-fledged national AI strategy. The strategy lays out a precise plan that calls for the construction of research labs dedicated to artificial intelligence (AI), the installation of high-performance computing (HPC) infrastructure, and the creation of a centralized "big data" repository by September 2025. In addition to infrastructure, Uzbekistan's policy aims to boost the knowledge economy by boosting exports of IT services and establishing the nation as a new regional center for AI research.

These advancements show how Central Asian nations are using AI to boost digital sovereignty and global competitiveness in addition to improving internal governance. Ad hoc digital initiatives are giving way to systematic, long-term policy frameworks that attempt to integrate AI into national development objectives, as seen by the quick institutionalization of AI programs.

6- Discussion

Different industries are developing at varying rates, according to the global adoption landscape of AI. Technology, retail, and financial services are leading the race in the short term, while manufacturing and energy are set to undergo significant change in the medium term. These insights should be interpreted by Kazakhstan as a roadmap to become the leader in AI in Asia, not just as benchmarks.

Kazakhstan already possesses inherent advantages that can be leveraged to gain a competitive edge. The nation is well-positioned to adopt AI in the transportation, logistics, and energy sectors—sectoral that the global table indicates will mature significantly over the next three to seven years—due to its strategic location, function as a logistics hub between Europe and Asia, and abundance of energy resources. Kazakhstan could establish itself as a regional leader if it makes a significant investment right away in AI-enabled supply chains, smart ports, predictive energy management, and green transition technologies.

At the same time, Kazakhstan could grow rapidly in industries like retail and financial services, where adoption is already widespread worldwide. With increasing proficiency in digital banking, mobile payments, and e-commerce, the nation boasts one of the most developed fintech ecosystems in Central Asia. By integrating AI for risk management, fraud detection, and customer personalization, Kazakhstan could not only catch up to world leaders but also establish new benchmarks for regional financial innovation.

Manufacturing and healthcare offer leadership opportunities as well as longer-term challenges. Kazakhstan has a window to catch up more quickly by investing in medical AI (telemedicine, diagnostics, predictive care) and smart industrial transformation, as global data indicates slower maturity in these areas. The nation could catch up to advanced economies more quickly than anticipated if national strategies like Digital Kazakhstan are matched with incentives for AI-powered healthcare startups and advanced manufacturing projects.

Kazakhstan will also need to make investments beyond sectoral applications if it wants to become a leader in Asia. There are three essential enablers:

- Building a skilled workforce through AI-focused education, collaborations with academic institutions, and retraining initiatives for current industries is known as AI Talent and Education.
- To support AI innovation, data infrastructure should be established, including strong data governance, open data platforms, and cloud infrastructure.
- Policy and Incentives: establishing a legal framework that promotes the use of AI, aids new businesses, and draws in foreign capital.

Kazakhstan could establish itself as a true AI leader in Asia and set the standard for other emerging economies in the region if it can combine early successes in fintech and retail with calculated mid-term investments in logistics, energy, and manufacturing, all the while fostering an environment that will allow AI to flourish.

7- Conclusions

This study focused on a responsible and sustainable implementation framework while examining the use of AI in BPM in the Kazakhstani context. Through an examination of enterprise information systems, privacy-focused modular architectures, and Kazakhstan's cybersecurity and data localization regulations, the study identifies the crucial circumstances in which the implementation of AI can yield enduring financial and organizational advantages.

The suggested framework for implementing AI-BPM places technological advancement in the context of Kazakhstan's larger strategic objectives of digital modernization and economic diversification. The responsible governance of data is essential to this, serving as a catalyst for innovation, resilience, and trust-building in the public and private sectors in addition to being a requirement for compliance.

Kazakhstan must prioritize sectoral focus and strategic timing to optimize its impact, as highlighted by our analysis of global AI adoption maturity. While consumer-facing industries such as retail and financial services show rapid near-term adoption potential, sectors like healthcare illustrate a more staggered path requiring infrastructure investment and talent development. However, Kazakhstan's economic structure and geopolitical location offer promising mid-term prospects in manufacturing, logistics, transportation, and energy areas vital to the nation's transition away from resource dependence and its role as a hub for Eurasia. Targeted investments in automation, smart technologies, and workforce upskilling could establish Kazakhstan as a regional leader in advanced industry, especially since manufacturing is expected to experience an 83% adoption surge in the medium term.

The results imply that Kazakhstan's comparative advantage is in strategically utilizing mid-term opportunities rather than in quick, near-term adoption. Thus, prioritizing infrastructure, bolstering data governance, developing AI talent, and encouraging businesses to use AI-enabled BPM solutions will be essential to success. Kazakhstan can outperform peers in crucial industries, turn structural bottlenecks into growth opportunities, and lay the groundwork for long-term digital competitiveness by coordinating investment timing with sectoral readiness.

All things considered, this study contributes to the conversation about responsible AI-enabled BPM in developing nations. Kazakhstan's path shows that AI can be used as a transformative opportunity and a governance challenge, even in environments that rely heavily on resources. In order to improve implementation models appropriate for economies at comparable stages of digital transformation, future research should investigate cross-country comparisons and empirically validate the sector-specific adoption pathways suggested here.

8- Declarations

8-1- Author Contributions

Conceptualization, S.S. and S.N.; methodology, S.S. and S.N; software, S.S.; validation, S.S. and S.N.; formal analysis, S.S., S.N., G.M., and B.A.; investigation, S.S. and S.N.; resources, G.M., B.A., and A.T.; data curation, S.S. and S.N.; writing—original draft preparation, S.S. and S.N.; writing—review and editing, S.N.; visualization, S.S.; supervision, G.M., B.A., and A.T.; project administration, S.S.; funding acquisition, S.S. All authors have read and agreed to the published version of the manuscript.

8-2- Data Availability Statement

The data presented in this study are available in the article.

8-3- Funding

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8-4- Acknowledgments

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8-5- Institutional Review Board Statement

Not applicable.

8-6- Informed Consent Statement

Not applicable.

8-7- Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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