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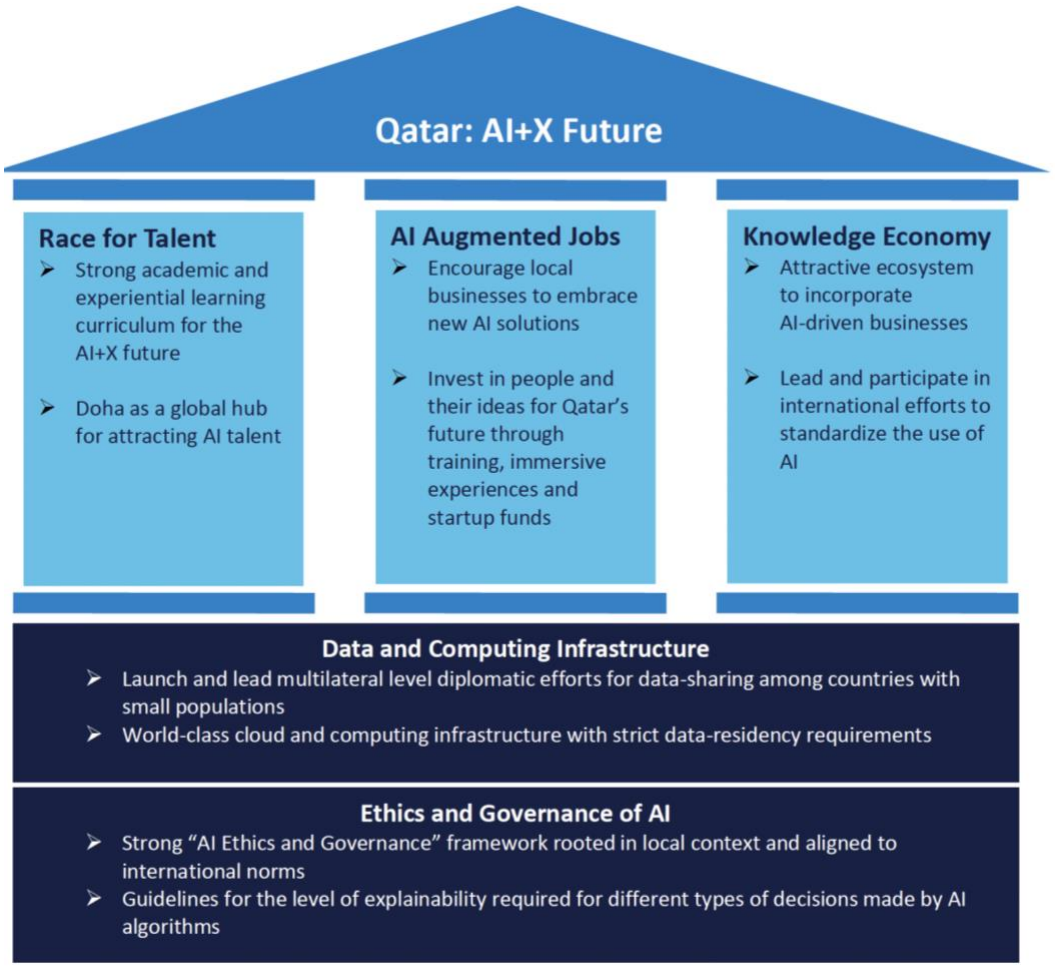
Ministry of Communications and Information Technology
State of Qatar • دولـــة قطـــر

NATIONAL ARTIFICIAL INTELLIGENCE STRATEGY FOR QATAR

EXECUTIVE SUMMARY

Artificial Intelligence (AI) based technologies have been steadily permeating into our lives. However, this is just the beginning. AI has the potential of upending how we conduct our lives, how the economy is transacted, and how our communities are organized. In this document, we provide an overview of AI in the context of Qatar as a country, identify the key pillars to build a great AI research and innovation ecosystem in Qatar, and follow those with recommendations for action.

Our vision is to have AI so pervasive in all aspects of life, business and governance in Qatar so that everyone looks up to Qatar as a role model for seamlessly transitioning into an AI+X future.



INTRODUCTION

Qatar needs an overarching AI strategy that supports the national vision and is rooted in its local context. The goal of this strategy is to leverage AI to secure Qatar's economic and strategic future, as envisioned in Qatar National Vision (QNV) 2030 and prepare the society for effective adoption of AI technology that is aligned with local needs and traditions.

The AI Strategy is structured around six thematic pillars which together will guide Qatar to transform itself for an AI+X Future. The moniker "AI+X" refers to the emerging consensus that AI technology will permeate into all secular aspects of human endeavors: health, entertainment, business activity, education and research. Modern AI is predicated on the use of data as a strategic resource. Raw data needs to be coupled with technological capability to produce new AI-driven products which will transform the normative basis of how societies operate and function. Having invested heavily in an education and research infrastructure, Qatar is poised to play a leadership role in an AI+X Future.

THE GLOBAL AI RACE

Artificial Intelligence (AI) is a transformative technology of the 21st century and one of the main arenas in which nations of the world will compete. The CEO of Google has stated that AI may be "more important than fire or electricity." This is an exaggeration, but it has become very clear that AI will transform all facets of human society - education, healthcare, transportation, business, entertainment, warfare, and more .

The origins of AI lie in the USA and the most recent developments in the field have come from North America. However, other countries are vying for "AI superpower" status. China aims to be the global leader in AI by 2030 and is investing heavily to achieve this goal, especially in the use of "Data" as a strategic asset. Countries such as Canada, Japan, and the UK have also adopted AI strategies that aim at global leadership. Other countries such as Denmark, Taiwan, and South Korea have developed AI strategies that do not necessarily aim at global leadership, but rather at promoting the use of AI throughout society and developing AI solutions for local needs[i].

Increasing local AI adoption is the beginning of a journey to become competitive as a society in the global economy. The leadership in many advanced countries have concluded that capacity building in AI technology is vital for a sustainable and viable economy.

As AI's leverage increases in a connected world economy, we will increasingly see a "winner takes all" trend dominating in businesses. This will have a serious implication on how nations, organizations, or even individuals think about building AI capacity and applications that are viable. In a world where innovative ideasand software can originate anywhere and thrive, excellence is not just a lofty goal to achieve but a necessary requirement. There is no escape from excellence in the impeding AI future.

WHY QATAR SHOULD PARTICIPATE IN THE AI RACE

Qatar is a forward looking nation and has a clearly stated vision of using its economic advantage derived from fossil fuels to transform itself into a knowledge-based economy.

Indeed, the investments that Qatar has already made in research and development efforts in AI can serve as a foundation to build strong capabilities in the area and provide a head start to make globally recognized AI-based solutions.

The following are the threats and opportunities in the AI future of Qatar:

Threats :

- Economic diversification has been identified in Qatar as an inescapable step towards becoming a knowledge-driven society. This implies that Qatar must become globally competitive in selective niche areas. As AI permeates into all sectors of human activity, **not competing in the AI arena will significantly hurt Qatar's plans of diversification.**
- AI-enabled automation will have a profound impact on the employment landscape in all countries. As Qatari citizens are overwhelmingly employed in administrative white collar occupations, **the threat of job tasks becoming susceptible to automation is very real in Qatar.**

Opportunities :

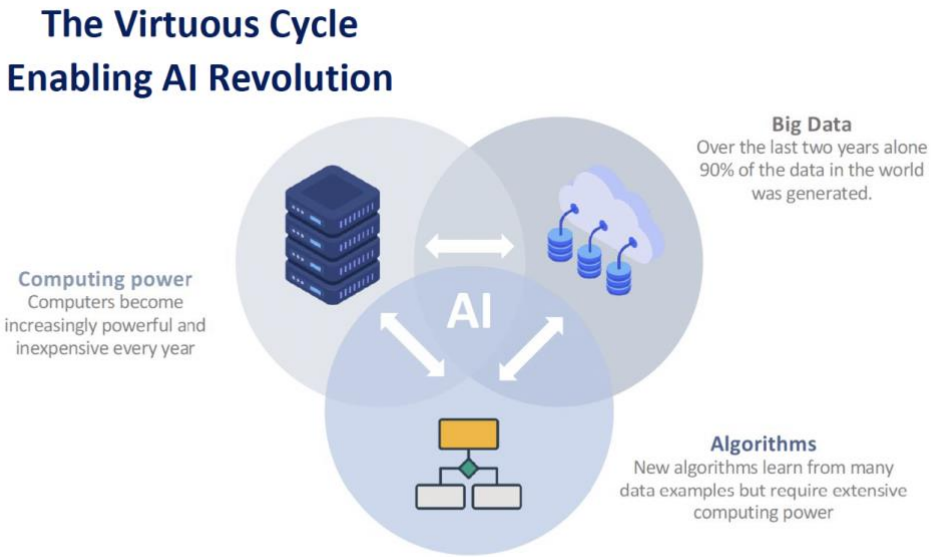
- Qatar has a small, educated and information technology-savvy population. Using AI derived automation to augment human capability that enhances both capacity and capability of the Qatari workforce is entirely possible in a reasonably short time horizon.
- By making judicious investment in AI technology, Qatar can accrue downstream benefits by **owning the future "means of production".**

AI SPRING – BIG DATA, ALGORITHMS, AND CLOUD

The term Artificial Intelligence is not new. It was coined in the summer of 1956 by a group of renowned American scientists[2]. However, the field of AI in its early days had a history of over-promising and under delivering. The public in the 1950's and 60's were fascinated by promises of "thinking machines" that can understand language, play chess, and diagnose diseases, only to be disappointed when none of these predictions materialized in a meaningful way. This led to periods of disenchantment with AI and withdrawal of funding for AI projects, the so called "AI Winters."

Since the 1990s AI has been able to deliver on its promises and there has been a much better understanding of its capabilities and its limitations. A narrow form of AI grounded in data has taken root and won over skeptics. AI was finally able to beat a world chess champion, drive a car autonomously, and defeat the two greatest champions in the Jeopardy! game show[3]. AI became an integral part of many technologies, such as web search engines, natural language processing, logistics optimization, robotics, and medical diagnosis.

The period since 2011 onwards can be truly called an "AI Spring." AI is no longer a technology component, but rather the main enabler for many business and scientific solutions, from image recognition to self-driving cars to targeted political advertisements. The confluence of Big Data, algorithms and access to cheap computing power through cloud computing has created:



PILLARS OF QATAR'S AI STRATEGY

The National AI strategy of Qatar has six pillars: education, data access, employment, business, research, and ethics. It envisions two roles for Qatar: First, **Qatar must become capable of producing world class AI applications in areas of national interest and have a business environment enabling the use AI as a driver for innovation.** Second, Qatar must be an efficient consumer of AI, with a properly educated citizenry, sound laws, and ethical guidelines.

The national AI strategy would be a powerful technological enabler for the Qatar National Vision 2030[4]. QNV 2030 is itself organized around four pillars: economic, social, human, and environmental, and AI is indispensable for all the four pillars. For example, the economic pillar calls for the development of a "knowledge-based economy." By investing in AI education and homegrown AI solutions, the effort to ground the economy on knowledge capital can be accelerated. Similarly, developing an endogenous AI-based capacity for promoting transportation efficiency can help reduce pollution and foster environmental development. There are six pillars that we have identified for Qatar's AI strategy. These cover all aspects of AI relevant to Qatar and provide a framework for organizing action plans and investments in the future.

Pillar 1: Race for Talent in the "AI+X" Era

Developing and even using Al technology requires special skills that are in short supply all over the world. Al is likely to be embedded in all aspects of human activity, a phenomenon that can be called **"AI+X".** There is massive demand for Al talent, driving up salaries and creating intense competition among companies to hire in Al related roles, such as data scientists and software engineers. Data science and Al courses at major universities and through online providers attract literally thousands of students. Thus, the first pillar of Qatar's national Al strategy should be education and training.

Qatar is uniquely positioned to reap the benefits of Al. More than 94% of the Qatari population uses the Internet, one of the highest rates in the world. Widespread Internet usage indicates that Qatari citizenry is constantly being exposed to Al- enabled technology, including computer vision, language and speech processing, and digital maps. When it comes to Al, the future has already arrived. Designing and producing Al-products that are optimized for local needs and usage is not as far fetched as it might seem and can be enabled by necessary education and training.

AI+X Paradigm: Al education should be an integral part of the curriculum at all educational levels in all disciplines. At the K-12 level, younger students should learn to deal with the recommendations of Al. For example, Al typically provides its recommendations in the form of probabilities, so students should learn the basics of decision-making in the face of uncertainty. The move away from sense-based towards intellectual perception is rooted in medieval Islamic philosophy[5]. Students should also learn about interacting with Al as part of their environment. For example, learning to reject the recommendations of Al that clearly disagree with common sense. Older students should have the

opportunity to learn technical and philosophical aspects of AI. It is also important to "teach the teachers" about AI by developing professional learning courses or online training.

At the university level, computing-related departments should prepare their graduates for careers in STEM and AI disciplines. Other academic departments should be attuned to the use of AI in their disciplines and educate their graduates to be prepared when they encounter it.

AI education also encompasses AI courses or boot camps that prepare those already in the workforce to work in AI-related jobs, especially if their current jobs can be replaced by AI. In addition, management and executive training that educates business leaders on the necessary basics of AI should be available[6].

Finally, **in addition to growing local AI talent, Qatar should attract top AI international talent** in education, research, and entrepreneurship by introducing fast-track residency permits and creating a tech-friendly investment environment.

RECOMMENDATIONS:

- **Develop a strong academic and experiential learning curriculum for the AI+X future** (i.e., projects/activity driven) for K-12 to build local capacity for managing interactions with AI, imagining/planning AI solutions from a young age, and building strong foundations in computational methods and STEM curriculum to develop AI applications in the future. Quantify the amount of necessary talent required in STEM disciplines to inculcate an AI ecosystem.
- Design degree programs with in-built apprenticeship pathways (e.g., AI based medicine) where students can interact with researchers and businesses for building Qatar-relevant AI applications.
- Promote a vibrant research and entrepreneurship ecosystem for innovative AI applications that naturally align with Qatar's national interest.
- **Adopt strategies for attracting top AI talent from all over the world** such as: internationally competitive incentives, fast-track residency, easy yet well-regulated data access to facilitate innovation, and policies to encourage integration of locally developed AI solutions.

Pillar 2: Data Access is Paramount

The current Al revolution is based on Big Data, and modern Al models require large amounts of data to train them. Data is the key asset that underpins the resurgence in Al and its usage and release needs to be strategically shepherded. One way for Qatar to quickly gain an Al advantage is to **develop data governance rules and guidelines that facilitate broad access to and sharing of data consistent with the recently released Qatar Data Privacy Laws**[7].

Data sharing among organizations or even within an organization is impeded by two considerations. First, data has strategic and monetary value to the organization there is a saying that "data is the new oil[8]." Second, data sharing can violate the privacy of users. People with data are (justifiably) worried about these two considerations when they share data, so the tendency is not to share.

Data release and sharing needs to be driven by a strategic imperative of enabling and promoting a local Al ecosystem. For example, China has been at the forefront of using data as a strategic tool to promote indigenous technology. Data is the "new source code" and this perspective needs to adopted by decision- makers in Qatar.

Qatar has the unique advantage of being a small country that is well connected administratively. This makes development of broad data sharing guidelines possible, and it can be one of the competitive advantages of Qatar in the area of Al.

RECOMMENDATIONS:

- Qatar should create a data strategy office responsible for educating government and business organizations and developing guidelines for the use of data as a strategic resource. Qatar should develop guidelines for data sharing that encourage people with data to share it and make clear the best practices for doing so. The guidelines should spell out the obligations of the receiver of the data. For government entities, these guidelines can be elevated to be mandatory policies.
- Qatar should **launch and lead multilateral level diplomatic efforts for data-sharing among countries with small populations.** For most countries, including Qatar, developing successful Al applications that can generate export revenue won't be possible without greater data sharing at a global level. There is no such multilateral initiative in the world, hence this is an opportunity for Qatar to take a leadership role.
- Being a small country with a very diverse population, Qatar should leverage locally collected data by integrating and curating in ways that allow it to be repurposed and hence democratizes development of novel futuristic applications.

Pillar 3: The Changing Landscape of Employment

There is an intense ongoing debate among experts about the impact that AI technology will have on the future of employment and jobs in the coming years. The extreme view is that AI technology will result in massive employment disruption as many tasks that currently require human involvement have the potential of being replaced by AI. In a highly cited work carried out by researchers at Oxford University, over 40% of jobs in the US are under risk of becoming automated[9]. Economic theory suggests that the long- term financial returns on capital tend to be higher than labor and, thus, those who own capital will benefit disproportionately from AI technology. This has the potential of causing social upheaval and disequilibrium.

The impact of AI technology on Qatar is likely to be very different from what other countries may experience. In fact, **Qatar can leverage the AI revolution to realize its vision of transforming into a knowledge based economy by carefully investing in strategically important AI technologies.**

Qatar is home to around 2.5 million people out of which approximately 10% are local Qataris and the rest are non- Qataris who reside in the country specifically on the basis of employment. Most Qataris working outside the military and security forces have white-collar occupations, primarily in the public sector. Many of these white-collar jobs are, in principle, susceptible to outright AI replacement or AI augmentation[10]. For example, according to the 2016 Qatar Labor Survey, 23% of the Qatari male and 28% of the Qatari female workforce is employed in clerical positions[11]. Single- skill white-collar positions such as these are most susceptible to automation. However nearly 40% of economically active Qatari's have a university education - one of the highest rates in the world. By embracing AI and encouraging its citizens to be AI-skilled, Qatar can become one of the first countries in the world where citizens and AI technology can work together in harmony.

Consider the example of Qatar's burgeoning medical tourism industry. Qatar is ranked 30th in the world[12] for medical tourism and is rapidly developing a world-class medical infrastructure with several hospitals having already obtained highly sought after international accreditation. AI technology can help Qatar accelerate the growth in medical tourism and provide knowledge jobs for Qatari citizens and residents. For example, international standards for the ratio of nurses to patients

range from 1:1 to 1:6 depending on the nature of the medical treatment. However, many of the procedural tasks that a nurse carries out, like checking patient health parameters

and delivery of medication, can be automated by existing AI technology. The replacement of these tasks will not only be cost-efficient, but will lead to higher quality of service as machines are likely to make fewer "human errors". Similarly, Qatar is home to people from over eighty countries and there are at least eight large subpopulations that speak distinct languages. An AI-based speech and language translation system for medical communication can be built bottom up in Qatar and exported to the rest of the world.
However, the more human-interaction aspects of the nurse and patient relationship cannot be automated and Qatari residents can be trained to carry out this particular aspect of the nursing function. Thus, the augmentation of a nurse job with AI technology can be used
to admit more patients per nurse, provide higher quality of care, and create specialized knowledge-intensive jobs.

History shows that once the cost of using a new technology falls below a certain threshold then that technology rapidly permeates through society[13]. It is hard to predict what new applications will emerge that will take advantage of the emerging AI technology. What remains constant is that economics is often the key driver of technology adoption. One of the factors affecting the cost of adopting AI in Qatar compared to other countries is the ability of Qatar to import low cost labor from the developing world. Thus, the cost of labor intensive and inefficient solutions is often less than the cost of an AI solution leading to a situation where long-term efficiencies are sacrificed for short-term benefits.

RECOMMENDATIONS:

- **Provide financial incentives to local businesses to embrace new AI solutions** and resist the temptation of using low-cost labor as a substitute for embracing AI technology.

- Educate/Train Qatari citizens in managing, building and investing in AI solutions for continuously improving the standards of living and economic productivity in Qatar.

Pillar 4: New Business and Economic Opportunities

Qatar has a modern, diverse, technology-driven business landscape. Besides a world leading oil and gas industry, Qatar is home to a major international airline, an influential financial sector, and a robust power generation enterprise. AI will transform the economic and business landscape in Qatar, and the national AI strategy should address this transformation. AI is already being adopted by businesses worldwide; McKinsey estimates that global technology companies such as Google and Baidu spent a total of $20-30 billion on AI in 2016[14]. These technology companies are the early adopters of AI, but investment in AI is also happening in other sectors such financial services, manufacturing, and agriculture. Early adopters are already seeing the benefits of AI, which is accelerating adoption by other companies.

The national AI strategy of Qatar should enable existing businesses to adopt AI, and **catalyze the creation of new businesses based on AI technology**. For example, the Qatari government can provide guidelines and best practices for businesses that plan to adopt AI, or even direct financial and technical assistance to these businesses to help them in adopting AI technologies.

Startup funds and incubators should be directed to focus on AI-based companies.

Since data is essential for modern AI, enabling access to the data that businesses need for developing their AI models can be a major driver of the adoption of AI in businesses. The other component of modern AI is a powerful computing infrastructure. This infrastructure can be partly provided by the private sector, but the government needs to play a role in ensuring that the computing infrastructure available to businesses is powerful enough to meet the demands of AI. For example, the internet connectivity within Qatar and internationally should support the capacity requirements of AI.

The government can accelerate the adoption of AI in the business sector by adopting AI in its own public services. That way businesses interfacing with AI- enabled public services will feel the need to become AI-enabled themselves. In addition, AI-enabled public services can be a quick success for AI that is felt by Qatari citizens. The Qatari government has a solid foundation on which to base AI adoption in public services, since Qatar already has a strong digital government, with services such as

Metrash, Hukoomi, and Baladiya/Oun[15]. It is befitting to augment these services with AI capabilities, resulting in more efficient service delivery that better responds to citizens' needs

RECOMMENDATIONS:

- Make investment commitments to develop programs for leveraging AI in areas of strategic importance for Qatar, e.g., oil and gas.
- Build a regulatory and incentive framework that is stable, and makes Qatar an **attractive ecosystem to incorporate by AI driven businesses around the globe.**
- Develop and maintain cutting edge computing and connectivity infrastructure with high degree of resilience.
- **Launch and participate in international efforts to bring standardization in all aspects of AI**, e.g., network and systems architecture, data and application integration protocols, requirements on of test case coverage, services, etc. that ensure a level playing field.

Pillar 5: Qatar - AI + X Focus Areas

In some cases, it is appropriate to procure existing AI solutions and deploy them in Qatar. However, there will be cases where it is imperative to develop local homegrown AI solutions. The reason can be that the solution addresses specific local needs of Qatar, that Qatar is uniquely positioned to be a global leader in developing the solution, or that the solution is highly strategic and must be controlled locally.
Qatar must ensure it has global AI research leadership in areas of national interest, and that local technology enterprises have sufficient technical capacity to develop AI solutions. Some example areas where it is imperative for Qatar to develop local AI solutions are as follows.

Arabic Language Processing:

As an Arabic speaking country, the use of AI for Arabic language processing should be a national priority for Qatar. Qatar has a wealth of content in Arabic that can be used to develop AI models, and Arabic language processing capabilities can enable impactful applications in education, media, security, and other areas of strategic importance. To illustrate, Qatar Computing Research Institute (QCRI) has developed multiple Arabic language processing systems such as an automatic speech-to-text system for Arabic that is in use by Al Jazeera media network, a suite of Arabic text processing tools known as Farasa that is considered the best in the world, and a powerful Arabic-to-English translation system. Qatar can be a world leader in the use of AI for Arabic language processing and generation.

National Security:

Cyber security has become an AI problem. Advanced techniques for identifying and mitigating cyber threats depend to a high degree on data analytics and AI. Additionally, using AI to analyze publicly available data can provide advanced warning of threats. Such highly strategic infrastructure should rely on homegrown and locally controlled solutions. Signals from social-media now constitute a major focus of attention by intelligence agencies around the world to infer security threats to a nation. By building local systems which correlate network and social media traffic can go long way in creating another layer of security for Qatar.

Precision Medicine and Systems Biology:

AI will radically transform the way healthcare and medicine is practiced. The holy grail of personalized and precision medicine and the concept of "from bench to bedside" is realizable with AI. A consensus is emerging within the medical research community that a systems biology perspective which harnesses multiomic (genomic, proteomic, metabolomic) data is necessary to make next generation medical breakthroughs.

The Qatar Genome Project provides fine-grained data about citizens of Qatar and should serve as the basis of uncovering persistent disease patterns in the local population. A high rate of consanguinity in the local population makes the Qatar genome data highly unique and its usage and release needs to be strategically guided. More lifestyle and clinical data can be acquired from wearable devices, electronic health records and even social media. High quality data along with the world class medical and bioinformatics research infrastructure including Hamad Hospital, Sidra Medicine, Weill-Cornell Medicine, Qatar Biomedical Research Institute (QBRI) and QCRI can catapult Qatar to the forefront of personalized medicine, emergency services, and AI based medical education and research.

Transportation and FIFA World Cup 2022 ™:

Qatar is undergoing a rapid expansion in transportation infrastructure, whether it is road networks, the new Hamad Port and Airport, and expansion of Qatar Airways and Qatar Rail. This is a unique opportunity to put in place AI-enabled infrastructure from the get go. Additionally, AI can help in managing the logistics challenges of the FIFA World Cup Qatar 2022™, and enhance the experience of fans in the stadiums and viewers at home. These AI use cases would then help build the tourism industry post 2022. Through its TASMU[16] program, the Ministry of Communications and Information Technology (MCIT), previously the Ministry of Transport and Communications (MOTC), and prior to that the Supreme Council of Information and Communication Technology (ictQatar) has already proposed several use cases to transform Qatar into a digitally "Smart" nation. A lot of those use cases strongly focus on data. Using AI, Qatar can become a role model for sustainable urban development by cutting emissions in energy production and manufacturing from its current globally highest per capita levels.

Food Security:

Food Security has been identified as a national priority by Qatar. There is a tremendous potential for applying AI technology at the food-energy-water nexus and many countries, mostly notably Netherlands, have taken the lead in promoting next generation precision agriculture and vertical farming techniques. There is a push to generate massive amounts of data at the finest granularity level in agriculture and create customized water and fertilizer usage plans, which increases crop yield and is environment friendly at the same time. AI will play a big role in achieving food security in Qatar and everywhere in the future when severe strain on yields and arable land is expected due to climate change. Furthermore, Qatar should develop customized AI-driven simulations to prepare contingency plans to maintain food supply pipelines in face of regional disruptions and threats.

Oil and Gas:

Qatar's mature oil and gas industry stands to benefit significantly from AI. Qatar-based companies have access to the most fine-grained logging data from gas operations which can be leveraged to create niche AI-products in the oil and gas sector. For example, the use of this data to develop solutions for predictive maintenance enabled could help realize tremendous efficiency gains and reduce production downtimes. AI will also enable data driven revenue management and logistics optimization.

RECOMMENDATIONS:

- Build applications using Arabic language processing for business use cases to become the leader in this domain among the Arab nations.
- Leverage AI expertise available within the country in strategically important domains for Qatar like oil & gas, transportation, health, and cybersecurity to build competitive advantage in specific use cases that could also generate export revenues in the future.
- Use FIFA World Cup Qatar 2022™ to collect data and pilot AI application ideas that could also benefit Qatar in the long run.

Pillar 6: Ethics and Public Policy

The increasing pervasiveness of AI in our personal lives and work poses many ethical and public policy questions. AI methods tend to acquire “black box” characteristics and sometimes are not amenable to fairness, accountability, or transparency principles that are vital for the long-term viability of societies and countries. AI algorithms will inherit any biases consecrated in data, and mechanisms are required that guarantee outputs which are consistent with societal norms[17].

Transparency and accountability require AI models to be explainable, i.e., the output of an AI algorithm be describable in plain natural language. In AI, interpretation is emerging as an important research topic of its own. For example, consider an AI algorithm that decides how patients should be prioritized to receive scarce organ transplants. If a “pure data” solution is used then an algorithm may inadvertently use longevity as a criterion and rank the patients based primarily on age.

Modern AI relies on data, including personally identifiable information (PII). For many technological companies, the user is a product and advertisers are the customers who pay a fee to access user information. There is an increasing push worldwide to treat private information as a human right and Qatar should use the recently introduced General Data Protection Regulation (GDPR) by the European Union as a template to introduce guidelines that protect its citizen from online exploitation[18]. MCIT had issued guidelines for the State of Qatar on privacy nd data sharing that are in alignment with the country's traditions and ambitions. These would form an excellent starting point to develop larger and a comprehensive set of guidelines for the country.

RECOMMENDATIONS:

- **The Qatari government should introduce guidelines for the level of explain ability and interpretability required for different types of decisions made by AI algorithms.**
- Build up from the existing guidelines on privacy, data sharing, etc. developed by MCIT.
- **Qatar should develop an "AI Ethics and Governance" framework for addressing ethical and public policy questions,** which will become increasingly important as the use of AI expands into sensitive areas of society such as policing, courts, health, and warfare.
- The framework to be developed must be consistent with Qatari social, cultural, and religious norms and international guidelines while ensuring that Qatar emerges as a leading proponent of AI.

CONCLUSION :

The proposed strategy provides specific recommendations for the leadership of Qatar to set course, embark and flourish in the brave new world of Artificial Intelligence.

Globally, the consensus has been building that the advent of Artificial Intelligence (AI) is the next technological inflection point at par with the industrial revolution, the benefits and consequences of which we are still witnessing. Those who can develop mastery in using and developing AI applications will reap its benefits and thrive. **Qatar is well positioned to take advantage of this golden opportunity and become a critical player in the AI economy of future.** However, we need to act with a sense of urgency to realize this opportunity before it becomes too late as the AI race among countries is becoming very competitive.

Qatar needs to act on the recommendations listed under the six pillars of the proposed national AI strategy to ensure it builds sustainable competitive advantages and remains a critical player in the global economy and society. This would require significant investments in the education and retraining of its citizenry to augment their existing capabilities with AI technologies and build an ecosystem conducive to developing path breaking AI technologies in Qatar.

NOTES :

1-A summary of the national AI strategies of some countries can be found at: https://medium.com/politics-ai/an-overview-of-national-ai-strategies-2a70ec6edfd. The following are examples of some of these strategies Denmark - *Strategy for* Denmark s *Digital Growth*- https://investindk.com/insights/the-danish-government-presents-digital-growth-strategy EU Commission - *Communication_Artificial_Intelligence forEurope* https://ec.europa.eu/digital-single-market/en/news/communication-artificial-intelligence-europe France - For a Meaningful Artificial Intelligence - Towards a French and European Strategy- https://www.aiforhumanity.fr/pdfs/MissionVillani_Report_ENG-VF.pdf Germany-Key points for a Federal Government Strategy on Artificial Intelligence https://www.bmwi.de/Redaktion/EN/Downloads/E/key-points-for-federal-government-strategy-on-artificial-intelligence.pdf?__blob=publicationFile&v=4 Japan Artificial Intelligence Technology Strategy https://pdf4pro.com/amp/view/artificial-intelligence-technology-strategy-nedo-7b342.html Nordic-Baltic Region - *Nordic-Baltic Region- Al in the Nordic-Baltic Region*- https://www.regeringen.se/49a602/globalassets/regeringen/dokument/naringsdepartementet/20180514_nmr_deklaration-slutlig-webb.pdf Taiwan Taiwan's Opportunities in the Al Industry - Sector Deal https://www.gov.uk/government/publications/artificial-intelligence-sector-deal

2. The term “Artificial Intelligence” was first used in 1956 and is attributed to John McCarthy, then a young assistant professor of mathematics at Dartmouth College, who organized a workshop named the “Dartmouth Summer Research Project on Artificial Intelligence” in the summer of 1956. McCarthy also co-invented the LISP programming language, which is popular in AI. An interesting perspective is provided by Jerry Kaplan’s informative 2016 book, “Artificial Intelligence: What everyone needs to know.”
3. Three highly popularized examples of AI defeating championship players in games of intelligence are IBM's Deep Blue defeating chess grandmaster Garry Kasparov in 1996, IBM's Watson defeating champions Brad Rutter and Ken Jennings in the quiz show Jeopardy! in 2011, and Google's AlphaGo defeating Go legend Lee Sedol in 2016

4. Qatar National Vision 2030 – https://www.psa.gov.qa/en/qnv1/Documents/QNV2030_English_v2.pdf
5. Islamic Philosophy https://plato.stanford.edu/entries/probability-medieval-renaissance/
6. A very good example of AI education for the broad population is Finland’s recent plan to teach 1% of the population the basics of AI: https://www.politico.eu/article/finland-one-percent-ai-artificial-intelligence-courses-learning-training/
7. Qatar Data Privacy https://compliance.qcert.org/sites/default/files/library/2020-11/Law%20No.%20%2813%29%20of%202016%20%20on%20Protecting%20Personal%20Data%20Privacy%20-%20English.pdf

8. Economist - *The world's most valuable resource is no longer oil, but data* - https://www.economist.com/leaders/2017/05/06/the-worlds-most-valuable-resource-is-no-longer-oil-but-data
9. Carl Benedikt Frey and Michael A. Osborne, "The Future of Employment: How susceptible are jobs to computerisation?" *Oxford Martin School Working Paper* - https://www.oxfordmartin.ox.ac.uk/publications/view/1314
10. "The AI Advantage – How to Put the Artificial Intelligence Revolution to Work" Thomas H. Davenport https://mitpress.mit.edu/books/ai-advantage
11. Planning and Statistics Authority - Labor Force Survey, Second Quarter (Q2) 2016 - https://www.psa.gov.qa/en/statistics1/pages/lateststats/20161012.aspx
12. https://www.medicaltourismindex.com/destination/qatar/
13. Prediction Machines: The Simple Economics of Artificial Intelligence Hardcover, by Ajay Agrawal, Joshua Gans , Avi Goldfarb https://www.amazon.com/Prediction-Machines-Economics-Artificial-Intelligence/dp/1633695670/
14. "Artificial Intelligence: The Next Digital Frontier?" *McKinsey Global Institute Discussion Paper*, 2017 https://www.mckinsey.com/~/media/mckinsey/industries/advanced%20electronics/our%20insights/how%20artificial%20intelligence%20can%20deliver%20real%20value%20to%20companies/mgi-artificial-intelligence-discussion-paper.ashx
15. Examples of Qatar Digital Government services:
- Qatar Digital Government – https://hukoomi.gov.qa/en/digital-project/qatar-digital-government
- Metrash for Ministry of Interior Services - https://portal.moi.gov.qa/wps/portal/MOIInternet/services/inquiries/metrash Qatar e-Government Portal – Hukoomi – https://hukoomi.gov.qa/
- Municipalities Services – http://www.mme.gov.qa/cui/view.dox?id=592&siteID=2 Oun application for municipalities services http://www.mme.gov.qa/cui/view.dox?id=743&siteID=2
16. TASMU https://tasmu.gov.qa/
17. The social and ethical ramifications of AI are receiving significant attention from research and public policy organizations. For example, the AI Now Institute at New York University (https://ainowinstitute.org/) has recently published a report outlining specific public policy recommendations to address ethical issues related to AI (https://ainowinstitute.org/AI_Now_2018_Report.pdf). The European Commission has drafted ethics guidelines for trustworthy AI (https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=56433). These activities can inform the development of Qatar's strategy. However, it is important to note that many of the ethical issues related to AI have to be studied in the context of local cultural norms. For example, a recent Nature paper that studied people's perception of what constitutes ethical AI actions in a particular context revealed significant cultural and demographic variations in what people perceive as "the ethical thing to do" (https://www.nature.com/articles/s41586-018-0637-6)
18. EU General Data Protection Regulation (GDPR) - https://eugdpr.org/