Mauritius Artificial Intelligence Strategy

November 2018

A report by the Working Group on Artificial Intelligence

Introduction

This report, 'The Mauritius Artificial Strategy', follows Government's dedication towards making AI a cornerstone of the next development model by recognizing the potential of the technology to improve growth, productivity and the quality of life, and makes recommendations to achieve objectives set. The report stems from deliberations held within the Working Group on AI, which is one of the three working groups reporting to a steering committee, set up under the Chairmanship of the Secretary to the Cabinet, to oversee and coordinate implementation of specific budget measures.

The Working Group met for 7 sessions over a month, with the Ministry of Finance and Economic Development providing logistical and administrative support while the Economic Development Board acted as secretariat to the Working Group and was responsible for writing the report.

The Working Group, in its discussions, focused:

- The potential applications of AI, in particular by matching the existing and new AI solutions to specific sectors and areas which could be of benefit to the economy
- the unique selling point of Mauritius in terms of AI,
- potential impact of AI,
- the appropriate ecosystem to nurture AI in Mauritius with focus on building collaborative communities,
- labour requirements, skills and technical expertise to sustain the ecosystem,
- the regulatory framework to enable the development of AI as well as possible incentives, fiscal or otherwise.

The members of the Working Group on AI comprised of:

- Mr. Georges Chung-Tick-Kan, Senior Adviser, Prime Minister's Office (Chairman)
- Mr. Anandsingh Acharuz, Director, Ministry of Finance & Economic Development Dr (Mrs) Yanembal Moorghen, Permanent Secretary, Ministry of Technology, Communication and Innovation
- Professor Dhanjay Jhurry, Vice-Chancellor, University of Mauritius
- Mr. Charles Cartier, Chairman, Economic Development Board
- Mr. Francois Guibert, Chief Executive Officer, Economic Development Board
- Dr. Arjoon Suddhoo, Executive Director, Mauritius Research Council
- Mr. Kem Mohee, Chief Executive Officer, State Informatics Limited
- Mr Avinash Meetoo, Senior Adviser to the Minister of Technology, Communication and Innovation

Executive Summary and Action Plan

1. Although the term Artificial Intelligence (AI) was coined in the 1950's, the recent breakthroughs putting in perspective the significant gains that can be achieved to the Economy and society at large have been based on the quantum leap of available data captured and generated by the unprecedented progress in innovative technologies in recent years, as well as quantum increase in computer power.

2. It is now widely accepted that Artificial Intelligence is capable of providing solutions to improve productivity globally and in almost every sector, thus pushing the production frontier and GDP potential in a way the steam engine and electricity have done to mankind.

3. Vladimir Putin, just to quote one of the several World leaders, recently stated in front of a young audience that" Artificial Intelligence is the future not only for Russia but also for all humankind and it comes with colossal opportunities……whoever will lead in Artificial Intelligence will also rule the world." A recent report by PWC estimates that AI could contribute $ USD 15 trillion to the world economy in 2030, an amount greater than the combined GDP of China and India.

4. At present more than forty countries, mostly developed economies, have either a strategy or a task force on AI. However each nation, given the high costs involved, is building its plan based on different aspects of AI policy such as research and development, capacity building and skill development, education, public and private sector adoption, ethics and inclusion, standards and regulation, data and digital infrastructure, to name just a few of the components of the eco-system that need to be developed to fully master AI.

5. As Mauritius moves up the economic ladder to become a developed economy, technology, innovation and skill development will play a key role in creating the first mover advantage in AI development in our region, the same way we created the first mover advantage in textile in the 1980's and offshore/global business development in 1990's and beyond.

6. Our working Group(WG) believes that AI and the other emerging technologies such as Internet of Things and Blockchain can address, at least partly, not only the economic, social and financial issues currently affecting our nation but can also be an important vector of revival of the traditional sectors of the economy as well as for creating a new pillar for the development of our nation in the next decade and beyond.

7. Our WG is proposing initially a strategy based on the identification of priority projects that are AI-enabled in the various sectors of our economy, skill attraction/capacity building for efficient and effective adoption, incentives to catalyze implementation and adoption of new technologies for improved public services delivery to support AI implementation. In the middle and long term, AI strategy will then scale up to become a new pillar to sustain our growth and economic development.

8. Our WG has identified several projects that could be good candidates for immediate implementation. The manufacturing sector which is one of the main pillars of our economy has seen its contribution to GDP dropped from 18% to 13 % in 10 years. The manufacturing industry has recently witnessed a surge in the application of AI and developers have come up with solutions that bring down costs, reduce defects and increase production speed. The proposed AI Council will look at the ways and means how the manufacturing sector can embrace AI to give the sector a new boost.

9. The Healthcare sector in Mauritius is metamorphosing itself into an integrated cluster underpinned by a core group of high value activities such as high-tech medicine and medical tourism. Global healthcare companies continue to invest heavily in AI to create super-speciality centres of excellence.AI based technologies are already significantly improving care quality, ranging from diagnosis of various diseases capability and care prescription to support of elderly care by AI powered robots .Mauritius can indeed take advantage of the various available use cases to reposition the industry for the benefit of the population and to affirm itself as a class healthcare regional hub.

10. Fintech is a new concept and is slowly replacing financial services as an industry as it continues to leverage technology to grow and render the sector borderless. Mauritius has already engaged in the Fintech revolution. Many companies in ICT/BPO and Banks are already engaged in several activities at different degrees of maturity such as in mobile applications, E-banking, digitization of platforms and business intelligence. All of these activities can further be fuelled with AI applications. Fintech applications are made to go beyond borders and AI will potentially be a huge enabler in our ambition to become the leader in fintech in the African region.

11. Agriculture is another sector seeing rapid adoption of AI and machine Learning both in terms of productivity growth and in-field farming technique. AI applications are fairly advanced in crop and pest management, precision farming such as optimum and harvesting time, accurate and efficient use of resources.AI application based on the analysis of high-resolution images and multiple sensor captured data could indeed improve land yields. AI can also track livestock and predators' movement for solutions and monitor animal sickness. It is felt that precision agriculture, smart irrigation, remote sensing technology, drone application, can help solve the growing problems in agriculture in Mauritius.

12. Recent developments by the Google Research team have demonstrated potential significant savings in energy through the use of AI in energy management and distribution. This is a low hanging fruit project that could benefit the country of tremendous savings in fossil fuel import and contributing to the reduction of our CO2 footprint.

13. Our WG has also identified Ocean Economy activities such as the concept of intelligent port and Maritime internet of things, Traffic management and security, the transformation of our roads into smart roads to reduce congestion, replacement of traditional lighting poles by AI powered smart poles, AI powered smart grid, can be determining factors in transforming Mauritius into a smart Society.

Recommendations

14. For Artificial Intelligence to have the required impact described above, there is a need to set up the Mauritius Artificial Intelligence Council (MAIC) made up of say 10 main members which will facilitate and oversee project implementation as well as quantifying the socio-economic impact. It will also set-up sub-committees to enlist the required expertise for the implementation of the various projects. It will define a roadmap along the line described in the WG Report. While it is felt that projects are to be driven by the private sector, Government should ensure a conducive environment through a robust and yet friendly regulatory, ethics and data protection environment and also through attractive incentives such as matching grants, tax credits and other fiscal incentives, training grants for investments in AI and other emerging technologies. In the light of the network of AI experts present at the World AI show in November, it will not be difficult to enlist foreign expertise to form the first AI Council. EDB will work with the different stake holders to form the Council which will then be responsible along with EDB to adequately structure the Council for effectiveness. It is reasonable to target early January 2019 for the appointment of MAIC Board members. The Council will then study and recommend a proper structure for operation to start within the next 2 months.

Working Group on AI
November 2018

Contents

Artificial Intelligence

Discussions around machines or artificial beings replacing or assisting men in their daily tasks by virtue of their own intelligence or consciousness since time immemorial, although the term Artificial Intelligence (AI) was coined in 1956 at the Dartmouth Conference.

Since, there has been a number of advances in robotics, programming, machine learning and deep learning over several decades, with recent breakthroughs putting in perspective the significant gains that can be achieved to the economy and society at large.

Artificial intelligence (AI) has over the years transcended from the science-fiction literature and movie baited utopia to a real possibility, capable of offering solutions to improve productivity globally and thus pushing the production frontier and GDP potential of the global economy in a way the steam engine or the internet have done in the past.

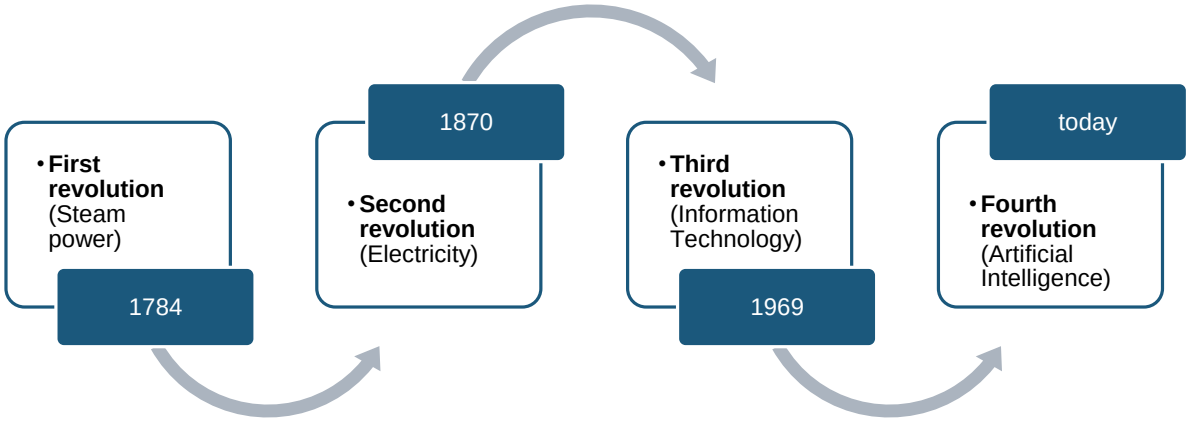


Figure 1: Global transformations

The re-emergence of AI on the international scene coincides today what is generally termed as the fourth industrial revolution, especially when placed in conjecture with internet of things, big data analytics, nanotechnology and blockchain, with discussions today more and more underpinned on the debate of how much will these technologies disrupt the world rather than if they will do it.

Demystifying AI

The practical applications of AI can already be noticed across several walks of life today, from virtual assistants such as Amazon's Alexa and Apple's Siri, Tesla's self-driving cars, to image recognition, to spot spam, robo-advisory, chatbots or detecting credit card fraud.

According to Accenture, at its core, AI is a combination of technologies *that allow smart machines to support human capabilities and intelligence by sensing, comprehending, acting and learning; thereby allowing people to achieve much more than can be achieved without AI.* These technologies include:

- natural language processing,
- intelligent agents,
- computer vision,
- machine learning,
- expert systems,
- autonomous cars,
- chatbots and
- voice recognition

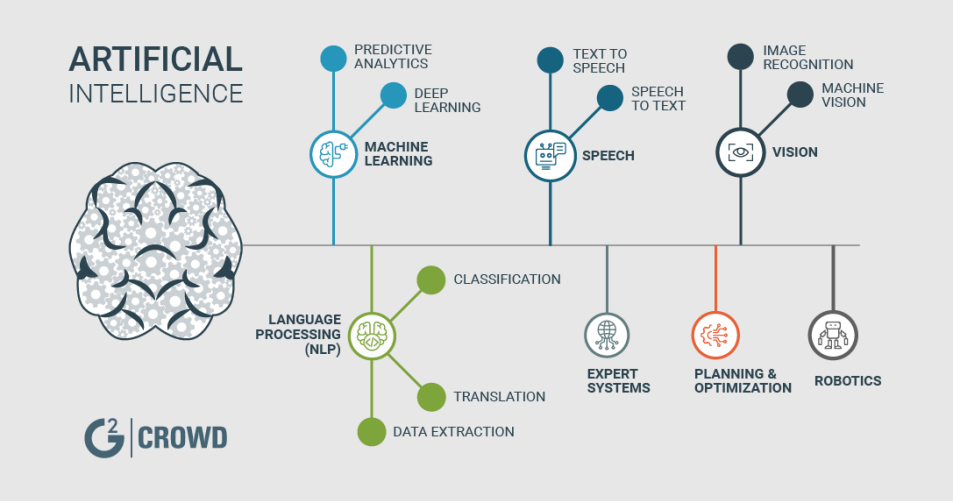


Figure 2: AI

When AI technologies are integrated, they can create a highly adaptable business capability and solutions that favour social inclusion. In fact, AI systems will typically demonstrate at least some of the following behaviors associated with human intelligence: planning, learning, reasoning, problem solving, knowledge representation, perception, motion, and manipulation and, to a lesser extent, social intelligence and creativity.

Basically, AI can be classified, at a very high-level, into:

(i) Narrow AI

Also known as "Weak" AI, it is the form of AI that is more prevalent in the world today. It is AI that is programmed to perform a single task, which could be checking the weather, playing games, translation, or analyzing raw data to write reports. It is not conscious, sentient, or driven by emotion and operates within a pre-determined, pre-defined range. Examples include Google Assistant, Google Translate, Siri and other natural language processing tools.

(ii) General AI

Also known as "Strong" AI, it refers to machines that exhibit human intelligence, and is capable of performing any intellectual task that a human being can. However, unlike humans, they cannot think abstractly, strategize, and tap into our thoughts and memories to make informed decisions or come up with creative ideas. Such AI should be able to reason, solve problems, make judgements under uncertainty, plan, learn, integrate prior knowledge in decision-making, and be innovative, imaginative and creative.

Opportunities from AI

AI A recent report by PWC, titled 'Sizing the Prize', estimates that AI could contribute up to $15.7 trillion to the global economy in 2030, which it estimates is greater than the combined GDP of China and India, with $6.6 trillion of it coming from the result of increased productivity and $9.1 trillion from consumption-side effects.

Economic effects

Initially, it is expected that productivity improvements will drive gains in output as firms indulge in AI technologies to automate routine tasks and roles, while the total economic gains by 2030 will come from product enhancements, stimulating consumer demand which will be the result of greater product variety, with increased personalisation, attractiveness and affordability over time.

The greatest economic gains from AI will be in China (26% boost to GDP in 2030) and North America (14.5% boost), equivalent to a total of $10.7 trillion and accounting for almost 70% of the global economic impact.

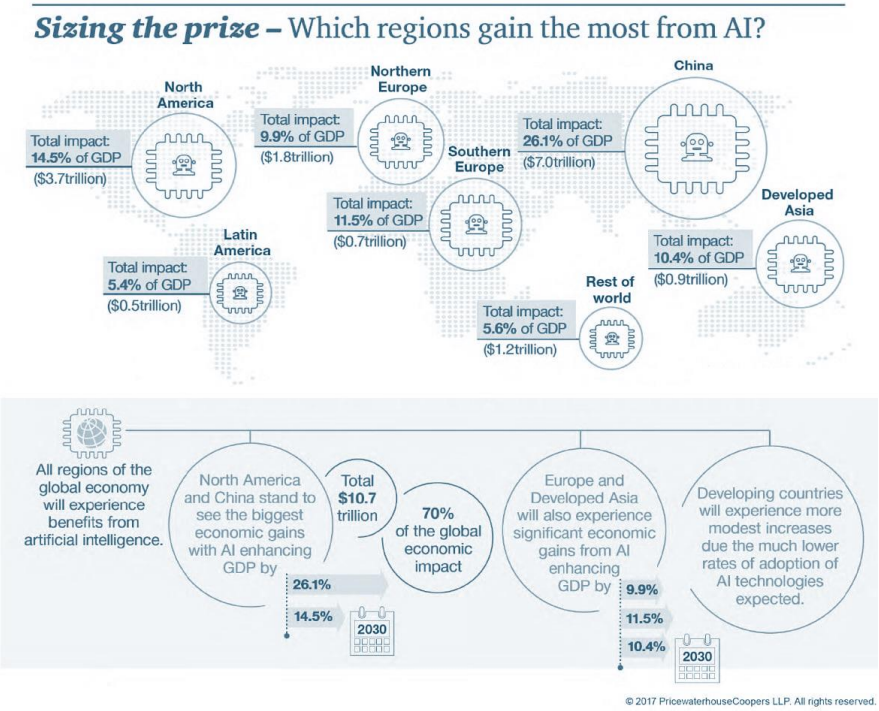


Figure 3: Regional gains from AI

Despite the fears that AI bring in terms of impending redundancies, by developing a new relationship between people and machines, there are significant challenges facing economies that the technologies can solve:

- Slow output growth, especially in advanced and large economies
- Falling capital efficiency
- Weak productivity (capital, labour and multifactor)
- Labor and capital augmentation by making more efficient use of the workforce and capital assets
- Innovation diffusion to stimulate new ideas
- Ageing workforce

Social effects

Over and above the economic benefits, AI technologies can be leveraged for the betterment of society and to address some of the challenges people face today in their daily life by promoting social inclusion and safety. Areas of focus where AI for social development is being used include:

- Social inclusion
- diagnosing diseases
- environment protection
- better public services
- fight against criminal activities
- transport

India for instance, in its National AI Strategy and *#allforall* initiative, has focused a significant portion of its actions on "AI for Greater Good: social development and inclusive growth", recognizing that disruptive technologies need to have positive externalities on quality of life and access to greater choice. Some areas it is considering include solving real-life social issues such as malnutrition, human trafficking and climate change through prediction and recommendation models using AI.

Benchmarking AI Strategies around the world

The potential impact of AI has forced countries and economic blocs to develop the appropriate strategies to ensure that the optimize on AI solutions to increase GDP and, in fine, the quality of life of citizens.

The strategies adopted by the different countries stand out it their heterogeneity, with each nation building their plan based on their uniqueness to focus on different aspects of AI policy such as research and development, capacity building and skills development, and education, public and private sector adoption, ethics and inclusion, standards and regulations, and data and digital infrastructure. Also, countries have different approaches to driving AI in the economy. For instance, UAE has set up a Ministry of AI for implementing the projects, while others have elaborated national plans with clear targets, such as India, France amongst many others. Kenya on the other hand has set up a task force to look into areas of financial inclusion, cybersecurity, land tilting, election process, single digital identity, and overall public service delivery, while Sweden has announced Guidelines and notes to encourage the private sector to invest in AI.

In fact, the US started off strong, with several reports in 2016 aimed at designing a plan to make the US an AI powerhouse, with the overarching objectives of boosting economic growth and improving national security. Although there has been no clear plan on the implementation of AI, recommendations were made by different instances for increased federal funding, regulatory changes, the creation of shared public data sets and environments, development of the manpower and ways for AI to improve cybersecurity and the military.

The change in Government had resulted in a reduction in AI research funds, although recent tax reforms could boost AI in the US. The lower corporate tax rate, provisions for repatriating cash from overseas and permission to expense 100 percent of capital investments is likely to spur investment in AI and other technologies. And the current administration's emphasis on deregulation could help AI in certain sectors, such as drones and autonomous vehicles. Other countries have been at the forefront of AI adoption and development. The UK launched in 2017 a plan to improve access to data, AI skills and AI research and uptake. In addition, funding for a Centre for Data Ethics and Innovation to drive responsible AI, for exploratory work on data trusts and for new AI fellowships and researchers was recently approved.

Canada, which already boasts impressive capacity in AI, has launched in 2017 its PanCanadian Artificial Intelligence Strategy, which includes funding for AI research centers in collaboration with private companies and universities. Japan meanwhile released an AI technology strategy with a three-phase plan to achieve a true AI ecosystem, building on successes in robotics, and other advanced technologies, such as the internet of things, autonomous vehicles and the blending of cyber and physical space.

Other countries with recently released national AI plans include Germany with ethical guidelines for automated driving and its Industrie 4.0 initiative, and the UAE with a strategy to use AI to boost government performance and various economic sectors. An interesting approach is also proposed by

India has taken a unique approach to its national AI strategy by focusing on how India can leverage AI not only for economic growth, but also for social inclusion. NITI Aayog, the government think tank that wrote the report, calls this approach AI for All.

The strategy aims to:

- enhance and empower Indians with the skills to find quality jobs;
- invest in research and sectors that can maximize economic growth and social impact; and
- scale Indian-made AI solutions to the rest of the developing world.

Proposed integration of COREs and ICTAIs | via NITI Aayog

NITI Aayog provides over 30 policy recommendations to invest in scientific research, encourage reskilling and training, accelerate the adoption of AI across the value chain, and promote ethics, privacy, and security in AI. Its flagship initiative is a two-tiered integrated strategy to boost research in AI. First, new Centres of Research Excellence in AI (COREs) will focus on fundamental research. Second, the COREs will act as technology feeders for the International Centres for Transformational AI (ICTAIs), which will focus on creating AI-based applications in domains of societal importance. Strategically, the government wants to establish India as an "AI Garage," meaning that if a company can deploy an AI in India, it will then be applicable to the rest of the developing world.

This demonstrates that AI offers solution to almost every country in the world, and there is a pressing need to be early adopters, especially regionally, to obtain and maintain a competitive advantage.

NATIONAL AI STRATEGIES

Canada	Pan-Canadian Artificial Intelligence Strategy (2017)	Attracting and developing research and talent	(1) increase the number of AI researchers and graduates, (2) establish three clusters of scientific excellence, (3) develop thought leadership on the economic, ethical, policy, and legal implications of AI, (4) support the national research community on AI.
China	A Next Generation Artificial Intelligence Development Plan Three-Year Action Plan to Promote the Development of New-Generation Artificial Intelligence Industry. (2017)	R&D, industrialization, talent development, education and skills acquisition, standard setting and regulations, ethical norms, and security	(1) developing intelligent and networked products such as vehicles, service robots, and identification systems, as well as AI's support system, including intelligent sensors and neural network chips, (3) investing in industry training resources, standard testing, and cybersecurity. (4) partnership with national tech companies to develop research and industrial leadership in specific fields of AI (5) $2.1 billion technology park for AI research in Beijing.
Denmark	Strategy for Denmark's Digital Growth (2018)	Adoption of digital technologies by businesses, improve conditions for the digital transformation of business and skills development, open government data, experiments with regulatory sandboxes, and strengthen cybersecurity	(1) creation of: (a)Digital Hub Denmark (a public-private cluster for digital technologies), (b) SME Digital coordinated scheme to support the digital transformation of SMEs, (2) The Technology Pact (a nationwide initiative to foster digital skills)
France	For a Meaningful Artificial Intelligence: Towards a French and European Strategy (2018)	AI research, training, and industry applications, regulatory framework, ethics	(1) National Artificial Intelligence Programme, which will create a network of four or five research institutes across France (2) Research and start-ups: €700 million will go towards research, €100 million this year to AI startups and companies, €70 million annually through France's Public Investment Bank, and $400 million to industrial projects in AI.
India	National AI strategy (2018)	India as an "AI Garage Skills development, investment in research and sectors that can maximize economic growth *and* social impact, deployment of Indian solutions worldwide	(1) Centres of Research Excellence in AI (COREs) will focus on fundamental research and act as technology feeders for the International Centres for Transformational AI (ICTAIs), which will focus on creating AI-based applications in domains of societal importance. (2) Healthcare, agriculture, education, smart cities, and smart mobility as the priority sectors that will benefit the most socially from applying AI. (3) Setting up a consortium of Ethics Councils at each CORE and ICTAI, developing sector specific guidelines on privacy, security, and ethics (4) Creating a National AI Marketplace to increase market discovery and reduce time and cost of collecting data
Japan	Artificial Intelligence Technology Strategy (2017)	R&D, talent, public data, and start-ups, productivity, health, and mobility	(1) the utilization and application of data-driven AI developed in various domains (2) the public use of AI and data developed across various domains, (3) the creation of ecosystems built by connecting multiplying domains. (4) Society 5.0 initiative— productivity, health, and mobility—and outlines policies to realize the industrialization roadmap.
New Zealand	Artificial Intelligence: Shaping a Future New Zealand (2018)	Awareness, data, skills development, fairness, transparency, and accountability in AI, economic and labour impact.	(1) developing a coordinated national AI strategy (2) creating awareness and understanding of AI in the public (3) assisting the public and private sectors adopt AI technologies (4) increasing access to trusted data (5) growing the local AI talent pool, (6) examining how AI affects laws and ethics.
Singapore	AI Singapore (2017)	Invest in the next wave of AI research, address major societal and economic	(1) Fundamental AI Research to fund scientific research that will contribute to the other pillars of AI Singapore.

		challenges, and broaden adoption and use of AI within industry.	(2) Grand Challenges supports the work of multi-disciplinary teams that provide innovative solutions to major challenges Singapore and the world faces. Currently the program focuses on health, urban solutions, and finance. (3) 100 Experiments funds scalable AI solutions to industry-identified problems. (4) AI Apprenticeship is a 9-month structured program to foster a new cohort of AI talent in Singapore. (5) Advisory Council on the Ethical Use of AI and Data to help Government develop standards and governance frameworks for the ethics of AI.
South Korea	Artificial intelligence strategy by the 4th industrial revolution committee (2018)	Develop AI talent, development of AI technology investment in infrastructure to support the development of AI start-ups and SMEs.	(1) six graduate schools in AI by 2022 with the goal of training 5,000 AI specialists (1,400 AI researchers and 3,600 data management specialists). (2) training of 600 people in AI to address the immediate short-term need for AI talent. (3) funding of large-scale projects in national defence, medicine, and public safety (4) AI R&D challenge similar to DARPA. This includes funding for the creation of an AI semiconductor by 2029 and an AI-oriented start-up incubator to support emerging AI businesses.
Taiwan	Taiwan AI Action Plan (2018)	Use Taiwan's information technology and semiconductor industries to develop new smart technologies	(1) AI Talent Program to cultivate 1,000 advanced AI researchers and 10,000 AI-related professionals by 2021. (2) Government to recruit global AI talents and make it easier for them to start work in Taiwan. (3) New pilot project based of the DARPA in the US and SIS in Japan in order to focus R&D into niche advantages for industrial development. (4) AI International Innovation Hub is being constructed with the aim of fostering 100 AI-related startups. (5) Policymakers are testing open data fields and flexible regulations to support development of intelligent applications. (6) Integrating AI technologies into the government's larger 5 + 2 industrial innovation initiative.
UAE	UAE Strategy for Artificial Intelligence (2017)	Use AI to enhance government performance and efficiency	(1) Ministry of Artificial Intelligence (2) Government investment in AI technologies in nine sectors: transport, health, space, renewable energy, water, technology, education, environment, and traffic
United Kingdom	AI Sector Deal (2018)	Boost public and private R&D, invest in STEM education, improve digital infrastructure, develop AI talent, and lead the global conversation on data ethic	(1) £300 million in private sector investment from domestic and foreign technology companies (2) expansion of the Alan Turing Institute (3) Creation of Turing Fellowships (4) Launch of the Centre for Data Ethics and Innovation

Table 1: National AI Strategies

Challenges with the implementation of Artificial Intelligence (AI)

Companies are adopting AI with a genuine sentiment that the technology will create a panoply of transformative opportunities to leverage the value chain process, get to market faster, service customers better, drive efficiencies and deliver competitive benefits. However, even if the technology appears business and user friendly, companies face multiple challenges in implementing AI solutions. Below are some of the key challenges that enterprises face while implementing an AI solution to its business process:

Lack of skilled human resources

AI is engendering a demand for new advanced skill sets in the workplace. There is an extensive shortage of talent that possesses the right understanding of the current AI technologies, its limitations, and applications.

The lack of skilled professionals who can build, maintain these technologies and direct a company's AI agenda prominently hampers progress and continues to be a major impediment for businesses around the world.

Businesses face a significant capability gap in recruiting the right talents such as data scientists, cybersecurity experts, computer scientists and IT specialists to get maximum output from AI. There is an unprecedented shortage of human resources with advanced skills in mathematics and sciences and a fundamental grasp of analytical and technical matters.

One of the key reasons for this AI skills crisis is that many of our academic institutions and training programs cannot keep up pace with innovation and new discoveries. Even if research showed that interest and investment are strong for AI, companies failed to define their AI strategy and invest in the appropriate training and upskilling mechanisms to foster leading AI practitioners.

Cybersecurity and Data Privacy Concerns

The implementation of AI-based solutions by business enterprises is raising a whole host of cybersecurity and data classification and privacy issues and stimulating a robust public debate globally.

It is advanced that AI applications face threats from cybersecurity attacks. This refers if the data used by AI are corrupted by hackers, the outcomes could be erroneous due to bias in data and algorithms and consequently cause harm to an organization by making incorrect and perhaps wrong predictions.

Additionally, the use of AI to existing regulatory framework has become a threat. It is important to recognize that data is a critical feature for AI and the way that AI systems learn is by using and analyzing data and make decisions without the need for human interaction. The greater the amount of data these AI systems have, the better the decisions become. It is clearly visible that the use of AI has implications for privacy, data protection and the rights of individuals. Poor data governance can result in an unintentional release of secure or private/confidential information where customers' personal identifiable information that feeds an algorithm may get into the hands of hackers and can cause legal challenges for the organization.

Loss of jobs

Artificial intelligence is advanced as an integral part of the new era. There is fear and concern by employees regarding AI and automation and how this technological change may lead to massive job loss.

Employees are concerned that AI will substitute, supplement and amplify all tasks currently performed by humans and subsequently eliminate a big proportion of the world's human labor and displace between millions of jobs requiring people to switch job categories entirely.

It is advanced that potential job loss on a major scale resulting from AI technology will have a direct and indirect impact on the job the market. One key direct impact of AI is a robot replacing employees or taking their jobs or an employee using AI solutions to increase productivity or switch to a new responsibility. An indirect impact is when a new firm using AI or developing a substitute product grows and puts the company the employee works to close.

Ethical/ Moral Challenges

The application of AI has raised numerous ethical/ moral challenges to the society in the ways in which AI systems implemented by business enterprises are making moral decisions in practical day-to-day situations in a variety of industries. It is difficult for human being to teach morality or fairness to machines that make it easy for a computer to process or provide machines with clear answers and decision rules to any potential ethical dilemmas it might encounter.

It is even debatable if we human beings have a sound understanding or precise conception of what morality or fairness is, that we can all agree on to effectively train machines to make better moral decisions. Failing to integrate ethics into AI system could amplify structural discrimination and reproduce biases in the data they are based on.

There is absence of standards in place to govern what's acceptable and what's not, or to outline what a company is responsible for because of AI-based decisions. A clear, explicit, and transparent code of ethics about what AI can and can't do needs to be established.

Skills development and capacity building

Artificial intelligence is a data-driven technology that is both powering autonomous machines and augmenting the flow of information and analysis for human workers. As machine learning evolves, workers must learn to adjust in much the same way as adapting to a new tool or software service.

AI is expected to have a significant impact on the competitiveness of both countries and companies and it has become clear that the demand for AI talent will far outweigh the available supply in both short and medium terms. According to a study by Element AI, there are only 22,000 PhD-educated AI researchers in the world—40% of whom are concentrated in the US. As a result, training of domestic talent is of paramount importance and countries are rushing to develop AI Master and PhD programs, short-term training initiatives, massive open online courses, and scholarships and fellowships. Almost every recent national strategy includes some combination of these initiatives to attract, retain, and develop AI talent.

Training and talent development as a key determinant

In the past fifteen months, Canada, China, Denmark, the EU Commission, Finland, France, India, Italy, Japan, Mexico, the Nordic-Baltic region, Singapore, South Korea, Sweden, Taiwan, the UAE, and the

UK have all released strategies to promote the use and development of AI. Though no two strategies are alike, common aspects of AI policy are scientific research, talent development, skills and education, public and private sector adoption, ethics and inclusion, standards and regulations, and data and digital infrastructure.

The availability of skilled manpower in AI is a necessity and the underlying premise of all the strategies is that AI will augment human employees rather than replacing them. It is thus important to ensure that employees are trained in the skills they need to work with AI.

Undoubtedly, AI specialists are one of the fastest-growing jobs in technology as advancements in AI over the last decade are presenting opportunities for companies to automate business processes, transform customer experiences, and differentiate products offerings. As AI permeates every industry, companies either need new hires to work on the AI or training to develop current employees' skills.

Overview of various strategies adopted

The shortage of AI talent remains an issue and the fierce competition for talent has contributed to a large uptick in acquisitions of AI companies. Early AI technologies and the forthcoming AI revolution are forcing organizations to reevaluate a number of established strategies. Instead of hiring the most qualified person for a specific task, many companies are now putting greater emphasis on cultural fit and adaptability, knowing that individual roles will have to evolve along with the implementation of AI.

On-the-job training has become more vital to transition people into new roles as new technologies are adapted.

Canada	The Pan-Canadian Artificial Intelligence Strategy is a five-year plan to invest in AI research and talent. The strategy has four goals: (1) increase the number of AI researchers and graduates, (2) establish three clusters of scientific excellence, (3) develop thought leadership on the economic, ethical, policy, and legal implications of AI, and (4) support the national research community on AI. Canada's AI strategy is distinct from other strategies because it is primarily a research and talent strategy. The new AI Institutes such as CIFAR Chairs in AI, and the National AI program — are all geared towards enhancing Canada's international profile as a leader in AI research and training.
China	The plan lays out the government's intention to recruit the world's best AI talent, strengthen the training of the domestic AI labour force
Denmark	The strategy has three goals: (1) make Danish businesses the best at using digital technologies; (2) have the best conditions in place for the digital transformation of business; and (3) ensure every Dane is equipped with the necessary digital skills to compete. The Technology Pact (a nationwide initiative to foster digital skills) has also been developed.
Finland	Key initiative included the creation of the Finnish Centre for AI (a joint partnership by Aalto and Helsinki Universities to increase AI research, talent, and industry collaboration), an AI accelerator pilot program, and the integration of AI in the public service.
Germany	Germany already has a number of related policies in place to develop AI. Principally, the government, in partnership with academia and industry actors, focuses on integrating AI technologies into Germany's export sectors. The flagship program has been Industry 4.0, but recently the strategic goal has shifted to smart services, which relies more on AI technologies

Table 2: Training and skills

Mauritius and AI

The 2018/19 Budget set the foundations for the emergence of a thriving ecosystem for AI under the theme "Harnessing Artificial Intelligence to Foster Innovative Entrepreneurship", starting with the setting up of a Mauritius artificial Intelligence Council (MAIC) comprising members from the public and private sectors, as well as international experts to spearhead and drive AI related activities and advise Government on the way forward.

This initiative builds on a series of actions taken by the Government of Mauritius to facilitate innovative firms to set up in Mauritius and foster a domestic entrepreneurial spirit in fields such as AI, IoT, Blockchain and Fintech. Some of these include:

a. The Regulatory Sandbox License

Around the world, there has been numerous Sandbox Licensing mechanisms that have mushroomed, with the pioneer being the Financial Conduct Authority in UK. The Mauritian Regulatory Sandbox License is more flexible in scope, and allows activities in areas where there are no or no adequate provisions in the existing regulatory framework. The EDB is responsible to manage the Sandbox, and works in close collaboration with regulators to provide the adequate framework for these activities.

b. Innovator's occupation permit

The minimum investment to qualify for an Occupation Permit, which is a combined work and live permit for foreigners willing to do business in Mauritius, is USD 100,000. However, entrepreneurs with new and creative ideas who want to set up a business in Mauritius, especially may not be eligible for an Occupation Permit since the initial investment requirement for such projects is less than USD 100,000.

In fact, such entrepreneurs are mainly based in home offices, but they will be involved in the development of innovative products in areas of technology, digital economy and biotech research which will spur productivity and economic competitiveness.

An innovator OP was launched to allow these innovative businesses to work in Mauritius, with an initial investment of only USD 40,000, subject to meeting a 20% percent requirement in terms of R&D expenditure.

c. Fiscal incentives

A company set up on or after 1 July 2017 and involved in innovation-driven activities for intellectual property assets which are developed in Mauritius can benefit from an exemption of 8 income years as from the income year in which the company started its innovation-driven activities.

The Government also allows double deduction of qualifying expenditure incurred for R&D purposes. "Qualifying expenditure" includes, inter alia, staff costs, consumable items, computer software directly used in research and development and subcontracted research and development.

In addition, there are a series of grants and schemes that favour the development of innovative projects. The Mauritius Research Council offers seven Innovation and Commercialisation Schemes as follows:

a. Collaborative Research and Innovation Grant Scheme (CRIGS)

It allows local companies or a consortium ranging from Micro, Small and Medium Enterprises, to Large Companies to submit proposals for innovative, collaborative research and development projects with commercial potential, in partnership with local Academic / Research / Tertiary Education Institution(s), awarding a matching grant of up to Rs5M per project to successful applicants for a project duration of normally up to 24 months.

b. Intellectual Property Promotion Scheme (IPPS)

The purpose of this scheme is to encourage individuals, enterprises, industry and R&D institutions to take advantage of the mechanisms for protecting innovation currently offered by the industrial property system in Mauritius. The IPPS, which operates as a joint collaboration between the Mauritius Research Council (MRC) and the Industrial Property Office (IPO), aims to boost creativity and innovation, initially through support towards applications made for the grant of Patents and registration of Industrial Designs.

c. Social Innovation Research Grant Scheme (SIRGS)

It is an innovative scheme to tackle an existing gap in social innovation in the local context. Social Innovation refers to the adoption of new social practices in order to meet social needs in a different or more effective way.

NGOs and/or public funded bodies in collaboration with academic/research institutions/private sector companies can submit proposals which combine action-research and a social innovation potential with tangible outcomes in social development research areas including but not limited to social integration of vulnerable groups, equal opportunities and environmental issues. A grant of up to Rs1M per project may be awarded for a project duration not exceeding 24 months.

d. *National SME Incubator Scheme (NSIS*)

The main aim of the NSIS is to encourage the creation of Innovative businesses for the socio-economic benefit of the Republic of Mauritius through a nurturing and training process in a conducive environment provided by Accredited Incubators driven by the private sector. The Accredited Incubators which will select, coach and mentor innovative business start-ups as early as the idea stage. The NSIS will fund (on a 50:50 matching grant basis) Accredited Private Sector Incubators at different incubation phases through accredited incubators funded by the NSIS. These phases are as follows: Pre – Incubation phase, Incubation Phase and Acceleration Phase

e. Proof of Concept Scheme (PCS)

It allows enterprises, entrepreneurs, researchers, as well as institutions, to submit applications under the Proof of Concept Scheme (PCS) in line with priority areas (Renewable Energy; Ocean Technology, Ocean Resources and Ocean Services; ICT/BPO/Telecommunications; Life Sciences; Manufacturing; Traffic Management; Social Issues; and Agro-Industry). Funding of up to MUR1 million per project may be available, for a project duration not exceeding 12 months.

f. Pole of Innovation Grant Scheme (PoIGS)

The Grant aims to enhance the impact of Research and Innovation on the economic development of the Republic of Mauritius by promoting creation of innovative products/ services and goods and spurring innovation through advanced research and partnerships among local institutions and/or companies and/or international stakeholders. Local academic and research institutions, both public and private as well as relevant Ministries/Parastatal Bodies are eligible for this scheme. The maximum grant allocated to successful applicants is Rs 9M per pole, with an annual maximum ceiling of Rs 3M, for a duration of 36 months. The applicant will have to match, both In Cash and In Kind, the funding requested from the MRC

g. Research and Innovation Bridges

It considers collaborative applications from consortia of company(ies), Research Organisation/ /Academic Institution from Mauritius and Partner Countries (each consortium containing participants from two or more countries), for innovative, collaborative research and development projects with commercial potential.

A matching grant of up to Rs10M may be awarded per project to successful consortium for a project duration of normally up to 24 months.

Challenges facing Mauritius

There are a number of internal and international challenges that may directly or indirectly affect the Mauritian economy in the next few years and its positioning as a key regional hub with regard to several sectors. Adoption of new technologies can act as mitigating measures to damp the adverse impacts of these challenges.

a. Falling productivity

The gap between growth in labour productivity and average compensation continued to widen, leading to a constant rise in unit labour costs. In 2017, labour productivity increased by 2.4 percent, while average compensation went up by 4.1 percent. As a result, unit labour cost rose by 1.7 percent. Sectors with the highest increase in labour productivity during the period 2009-2017 were administrative and support service activities, ICT and financial services.

b. Moderate growth

It is noted that since 2010, the Mauritian growth rate has been nearly at par with the average global growth rate and stagnating at around 3-4%. Together with the global slack closing – a first since 2008, it is anticipated that the Mauritian growth rate may remain subdued in the short to medium term. Although Mauritius has not known a recession since the early 1980's, any global recession may now have direct major impacts on Mauritius. It is therefore necessary to further improve efficiency and push forward our production capacity to build a more resilient economy while ensuring we achieve the growth rates required to graduate into a high income economy.

c. Technological adoption, Innovation and IP

As Mauritius moves up its economic development ladder, technology, innovation and know-how will play a key role in defining sectoral competitiveness and productivity. However, in many situations, the adoption of technologies and innovative ideas is slow or reluctant. For example, massive sensor and programmable logic controllers to drive the 4th industrial revolution and

embrace such sectors like domotics, robotics, etc. have been slow. On the other hand, adoption of blockchain backed technologies and other Fintech related applications are seeing significant reluctances. Finally, a knowledge-based industry clearly requires the protection of intellectual property which is the key denominator in guarantying long-term revenues from actual research and development projects.

d. Declining and ageing population

As Mauritius aspires to graduate to a high-income economy, it is imperative to address structural challenges such as lack of adequate skills to develop new sectors, a looming economic bane of a rapidly ageing population, and cumbersome administrative processes to allocate permits for both high skilled and low skilled workers. Without a new strategy, there will be a worsening of the dependency ratio. Indeed, today, 100 working persons are contributing for 58 non-workers. By 2100, the latter figure will rise to 100.9, which could impose severe pressure to increase taxes. The proportion of elderly (65+) will increase from around 10% of the population today to 26.1%, while the working age population will gradually fall to 55.9 % from 63 % today according to UN Population Prospects 2017. It, thus, becomes imperative for the Mauritius to embrace new technologies that will resolve the skill mismatch issue and build resilience to reduce the dependency ratio or render the latter more sustainable.

e. Social issues

There are a number of social issues plaguing Mauritius, such as drug abuse, congestion, law and order and road accidents. Global warming and erratic weather conditions cause much ground for concern as well. It is therefore important that due consideration is given to means to address these issues more efficiently through technology.

Adoption of AI in Mauritius

AI and other emerging technologies can address, at least partly, some of these issues. This report aims at providing a roadmap defining the key considerations for the development of the right ecosystem to enable Mauritius to adopt new technologies as enablers of growth for the next decade. The main focus areas of the strategies include:

(i) Prioritization of sectors and identification of national projects
(ii) Skills attraction and capacity building
(iii) Incentives to catalyse implementation
(iv) Ethical considerations of AI
(v) Development of strategic alliances in emerging technologies
(vi) Sensitization campaigns
(vii) Adoption of new technologies for improved public services delivery

Artificial Intelligence for business

Applications

Manufacturing

The World is moving toward Industry 4.0 or the Fourth Industrial Revolution very fast, where Artificial Intelligence (AI) and Machine-Learning (ML) based systems are not only changing the ways we interact with information and computers but also revolutionising the Manufacturing Sector.

The manufacturing industry has recently witnessed a surge in the application and implantation of Artificial Intelligence as the technology has matured accompanied by drop in costs. AI developers have also come up with new application possibilities and algorithms allowing more complex decisions.

Major companies including GE, Siemens, Intel, Funac, Kuka, Bosch, NVIDIA and Microsoft are all making significant investments in machine learning-powered approaches to improve all aspects of manufacturing. The technology is being used to bring down labour costs, reduce product defects, shorten unplanned downtimes, improve transition times and increase production speed.

Smart manufacturing supported by industrial IoT and AI is projected to grow noticeably in the next 3 to 5 years, according to market intelligence provider TrendForce. The firm estimates that the global smart manufacturing market will be well over $200 billion in 2018 and will increase to over $320 billion by 2020. That is a projected compound annual growth rate of 12.5 percent. Similarly, the International Federation of Robotics estimated that by 2019 the number of operational industrial robots installed in factories will grow to 2.6 million from just 1.6 million in 2015.

The manufacturing business requires high initial investments with relatively low returns. As such, traditionally, manufacturing companies have been driven to operate in low-wages countries where investment in AI would have seemed unreasonable. However, with the globalisation trend, the movement towards high income has become inevitable and manufacturers located in the emerging markets do not have any other option than to invest in AI to bring down production costs and stay competitive.

In 2018, the following applications of AI have been identified in the manufacturing sector:

- Process and operations optimization
- Root cause analysis based on machine learning
- Non-destructive testing
- Asset Management, Supply Chain Management, and Inventory Management
- Adoption of machine learning and analytics to improve predictive maintenance generate a 10% reduction in annual maintenance costs, up to a 20% downtime reduction and 25% reduction in inspection costs
- Machine learning for supply chain forecasting- expected to reduce forecasting errors by 50% and consequently reduce costs related to transport and warehousing and supply chain administration by 5 to 10% and 25 to 40%, respectively
- AI and machine-learning algorithms into procurement, strategic sourcing and cost management

The Manufacturing sector in Mauritius

The manufacturing industry remains one of the main pillars of the Mauritian economy and contributed 13.3% to GDP in 2017. The breakdown in terms of sub sector contribution is: Food (excl. sugar) 35%, Textile 29%, Sugar 1% and Other Manufacturing Activities 35%. Its contribution to GDP has however been gradually declining from a peak of 18.6% in 2006 to 13.3% in December 2017. In terms of employment, the manufacturing industry employed 98,700 people in 2017, representing around 20% of total employment.

Figure 1 below shows the manufacturing sector contribution to GDP (%) over the last 5 years.

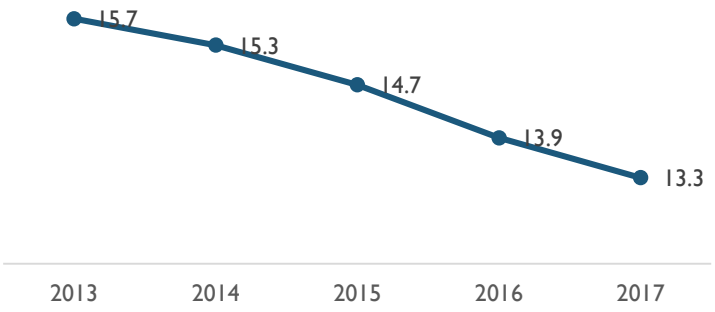


Figure 4 Manufacturing sector contribution to the GDP

Statistics clearly demonstrate a decrease in the contribution of the manufacturing sector in the economy and this is evidence for the loss of interest of promoters in the sector. Several manufacturing companies have closed down to relocalise elsewhere due to the increasing production costs in Mauritius.

This would be about the right time for companies to invest in AI to leverage on the available applications to bring down production costs and remain competitive.

The main labour intensive components of the Mauritian manufacturing sector are the sugar, textiles and clothing, Food and Beverages and precision engineering companies, inter alia.

With the rise in labour cost, the ageing population and the fad for the new generation to work in the services and finance sectors, the manufacturing industry can only survive if automation and AI is taken on board so as to sustain the profitability of the sector.

It has indeed been observed that the major operators in the manufacturing sector, in an effort to remain sustainable, have started investing in the implementation towards industry 4.0. Most machineries and equipment installed over the last decade, irrespective of the sector of activity or product, have the basic platform for the eventual implementation of automation and AI. Actually, there are many companies who have already implemented components of AI, at various degrees, and using AI at some point in the value chain would not require huge investments.

Key benefits of using AI in manufacturing

By implementing the right AI technology, a company can:

- save time and money by automating routine processes and tasks
- increase productivity and operational efficiencies
- make faster business decisions based on outputs from cognitive technologies
- avoid mistakes and 'human error', provided that smart systems are set up properly
- use insight to predict customer preferences and offer them better, personalised experience
- mine vast amount of data to generate quality leads and grow the customer base
- achieve cost savings, by optimising resources and products
- increase revenue by identifying and maximising sales opportunities
- grow expertise by enabling analysis and offering intelligent advice and support
- Having the right AI applications allow manufacturers to make more informed decisions at each stage in the production process in real time.

- In the case of production, with the use of sensors, AI spot defects in real time on the production line and immediate action is taken to remove defects as well as to bring the appropriate adjustments to prevent the defects to repeat

With real-time problem-solving, manufacturers can achieve potential cost savings defects, repairs and down time.

Textiles

The textile sector has been an important pillar of the Mauritian economy for more than 4 decades before knowing a drastic decline over the last 5 years due to fierce competition. In 2017, the textile industry contributed to 8.7 % to the economy and was employing 45,000 persons with 174 companies. Costs of operation have increased and there is an acute need for process optimization and optimised resources utilization for the industry to survive, which can now be achieved by many AI applications developed for the purpose.

For example, in garment manufacturing, fabric yield is of great importance as fabric represents up to 65% of the total garment cost. Thus, optimising the cutting department is critical and one big textile factory has totally automated its cutting department and is controlled by AI. The machine is connected and is always benchmarking with data available online to ensure that the optimum yield is obtained at all moment and for all products.

Similarly, another factory producing denim, uses AI for real time defect detection during production and automatically perform required machine adjustments, so as to prevent or minimize waste generation.

Other fields of the textile industry where AI applications can be used to improve efficiency and augment the capabilities of their human employees are:

- Detecting and eliminating yarn imperfections during spinning
- Fabric pattern recognition in weaving and knitting mills
- Inspection of printing quality
- Intelligent colour matching based on historic and current data
- Fabric Finishing parameters

Currently applications are being developed where machine learning will potentially enable business to find patterns and correlations between fibre properties, process parameters, yarn properties, machine settings, and fabric performance. This might help textile businesses to discover interrelationships that were previously undiscovered thus aiding in improving efficiency and maintenance. This includes providing integrated processes in production, quality, cost, information, statistical process control, just-in-time manufacturing and computer-integrated manufacturing. Expert systems and artificial neural networks are currently being introduced in modern textile industries.

Sewbots, designed to revolutionise the textile industry in the near future

The Sewbot, currently being developed by SoftWear Automation in America is an automatic sewing robot which uses a highly calibrated machine vision to watch and analyze fabric. It detects distortions and robotically adjusts the fabric. Working across a 70-foot long t-shirt production line, the robot performs each task, including cutting, sewing a seam, adding a sleeve, and quality inspection. Each step of the way, the computer vision guides the fabric. It starts with the programming, so that when the designer designs the good in 2D or 3D, the sew data is embedded in the file that goes right to the robot. The Sewbot currently has limited capabilities but is expected to revolutionise the textile industry in the near future.

Food and beverages Industry

The Food and Beverages industry is a growing one in Mauritius and comprise around 120 large establishments, employing up to 13,000 people. The competition is tough, particularly with regards to imports from Malaysia, China, South Africa and many other countries.

Consumers are constantly demanding more for less and the industry needs to look for new ways to satisfy customers while keeping costs low. Nowadays this is better done by AI applications than the human counterpart.

Integrating AI into the food business can dramatically reduce human errors and hike up quality, leading to an increase in consumer satisfaction and, eventually, sales.

There are a number of AI applications which have already been implemented in the F&B processing industry in a number of international company and Mauritius should follow to be able to stay competitive.

It should be however noted that most F&B companies in Mauritius are automated to various degrees and the leap to AI implementation should not incur very high investments.

Some of the AI applications that would be useful to the Mauritian F&B industry are:

Sorting Food

It can be quite time-consuming to sort fresh produce in order to prepare them for the manufacturing of canned and bagged goods. For example, sorting the size of potatoes can help manufacturers make decisions regarding which ones should be made into French fries, potato chips or hash browns.

The system uses sensor-based optical sorting solutions with machine learning functionalities. It utilises cameras and near-infrared sensors to view food in the same way that consumers do and sorts it based on this data, saving time and money and improving the quality of products.

Improving the Supply Chain

AI helps in supply chain management as food safety regulations have become stricter and companies need to be more transparent about their operations. The technology helps companies test and monitor food safety products at every step of the supply chain. It helps in creating more accurate forecasts to help manage pricing and inventory, while it also tracks products from farm to consumer to offer transparency.

Ensuring Personal Hygiene

AI is also helping to improve personal hygiene in a food plant, which is just as important as hygiene in a kitchen and helps to ensure that a facility is compliant with regulations. The system, which can also be used in restaurants, uses cameras to monitor workers and it uses facial-recognition and object-recognition software to determine if workers are wearing hats and masks as required by food safety laws. If it discovers a violation, the software extracts the screen images for review, and the technology is reportedly accurate more than 96% of the time.

Cleaning Processing Equipment

Another important element of maintaining health standards is with advanced processes that help to clean equipment. University of Nottingham researchers are developing a system that uses AI to reduce cleaning time and resources by 20% to 40%. It's called Self-Optimising-Clean-In-Place, or SOCIP, and it uses ultrasonic sensing and optical fluorescence imaging to measure food residue, as well as microbial debris in a piece of equipment, followed by optimising the cleaning process.

AI and predictive maintenance

Maintenance is a key area that can drive major cost savings and production value around the world. The cost of machine downtime is high: according to the International Society of Automation, $647 billion is lost globally each year. Over the years, businesses have overhauled maintenance processes to alleviate downtime and improve effectiveness but the best way to use data in the quest for optimum operational efficiency had been missing.

With AI and machine learning, it is now possible to process massive amounts of sensor data faster than ever before. This gives companies an unprecedented chance to improve upon existing maintenance operations and even add something new: predictive maintenance.

One industry that can expect to see unprecedented savings from AI is manufacturing. While most manufacturers are already using some form of preventive or predictive maintenance, AI can usher in a new era of productivity.

AI predictive maintenance uses data from various sources like historical maintenance records, sensor data from machines, and weather data to determine when a machine will need to be serviced. Leveraging real-time asset data plus historical data, operators can make more informed decisions about when a machine will need a repair.

Predictive maintenance tools upgrade the existing maintenance systems by using AI to ensure that people have the right knowledge and tools to keep mission-critical assets running at peak performance. Altogether, predictive maintenance allows for an optimised maintenance frequency and machine parts utilisation, leading to huge cost savings.

For example, in heavy machineries, the shafts and ball bearings of heavy rollers are constantly under pressure and to prevent unplanned downtimes, are changed at some predefined frequency as part of preventive maintenance. With the implementation of AI, it is now possible to use data from sensors measuring parameters such as temperature, vibration, friction so as to predict the exact time for replacement. This prevents undue replacements resulting into cost savings.

Case study of AI and manufacturing- General Electric

General Electric is the 31st largest company in the world by revenue and one of the largest and most diverse manufacturers on the planet, making everything from large industrial equipment to home appliances. It has over 500 factories around the world and has only begun transforming them into smart facilities.

In 2015 GE launched its Brilliant Manufacturing Suite for customers, which it had been field testing in its own factories. The system takes a holistic approach of tracking and processing everything in the manufacturing process to find possible issues before they emerge and to detect inefficiencies. Their first "Brilliant Factory" was built that year in Pune, India with a $200 million investment. GE claims it improved equipment effectiveness at this facility by 18 percent.

The goal of GE's Brilliant Manufacturing Suite is to link design, engineering, manufacturing, supply chain, distribution and services into one globally scalable, intelligent system. It is powered by Predix, their industrial internet of things platform. In the manufacturing space, Predix can use sensors to automatically capture every step of the process and monitor each piece of complex equipment.

With that data, the Predix deep learning capabilities can spot potential problems and possible solutions. GE spent around $1 billion developing the system, and by 2020 GE expects Predix to process one million terabytes of data per day.

GE now has seven Brilliant Factories, powered by their Predix system, that serve as test cases. It claims positive improvements at each. For example, according to GE their system results in, their wind generator factory in Vietnam increasing productivity by 5 percent and its jet engine factory in Muskegon had a 25 percent better on-time delivery rate. They claim it has also cut unplanned downtime by 10-20 percent by equipping machines with smart sensors to detect wear.

Key Challenges

Implementation of AI in manufacturing organisations have the following basic technologies, which can be quite costly:

- A smart factory will need to be networked, taking data from production lines, design & engineering teams, and quality control to form an integrated, intelligent operation.
- If manufacturers don't have the right smart machines and the right data collection points, it's just data with little or no insight, and insight is what creates world class optimised operations.
- Need for new skills to be able to manage and sustain the AI technology

Succeeding in AI implementation

Gartner, the world's leading research and advisory company gives below advices for companies to smoothly implement AI in their businesses:

Begin by aiming low with AI projects

Given that AI is a relatively new concept and organisations still have a learning curve ahead of them and need to better understand artificial intelligence applications in their line of business, it is advised that a company aims low first until it fully understands and masters the implications of using AI.

Focus on augmenting people

The replacement of people by artificial intelligence and related technologies such as robotics has been cause of concern since long. While organisations always aim for less overhead and maximum cost savings, the focus should be more on how to utilise artificial intelligence to augment a worker's capabilities, rather than to replace the worker. This helps to avoid resistance and also align with what AI really is, that is a decision-enabler.

Plan for knowledge transfer

AI management skills are scarce. As such it is essential to make sure that during AI projects there is a proper knowledge transfer from the supplier to the organisation. On top of being able to understand, manage and exploit data, it is key to make sure the right data are fed to the AI engine in order to get the right outcomes. This is key and needs to be understood in the organisation as part of that knowledge transfer. Gartner predicts "that through 2022, 85 percent of AI projects will deliver erroneous outcomes due to bias in data, algorithms or the teams responsible for managing them".

Select the proper AI solutions in the initial stages

Gartner advises to choose transparent AI solutions in initial stages so as to have an insight into how the AI engine comes to specific decisions so as to build up the confidence in using AI.

Conclusion

Automation, robotics, and complex analytics have all been used by the manufacturing industry for years. For decades entire businesses and academic fields have existed for looking at data in manufacturing to find ways to reduce waste and improve efficiency. Manufacturing is already a reasonably streamlined and technically advanced field.

As a result, the utilisation of more advanced AI is less likely to cause massive disruption but will look like evolution rather than a revolution.

Greater industrial connectivity, more widely deployed sensors, more powerful analytics, and improved robots are all able to squeeze out noticeable but modest improvements in efficiency or flexibility.

Applications of AI in manufacturing boil down to:

- Computer vision- for microscopic vision
- Generative design- generates optimal design as per input parameters and leverages on machine learning
- Digital twins- virtual model of a process, product or service for out of site optimisation
- Predictive maintenance- Use of sensors and advanced analytics for machines to report their conditions in real time

The newer applications of machine learning produce relatively modest reductions in equipment failures, better on-time deliveries, slight improvements in equipment, and faster training times in the competitive world of industrial robotics. Though these improvements may seem small, when added together the total potential saving is significant. According to the UN, worldwide value added by manufacturing was $12.3 trillion in 2016 and this is why companies are spending billions on developing AI tools to squeeze a few extra percentage saving out of different processes.

Currently, mass production is the dominant model in manufacturing since tailor made is too expensive due to high costs involved in redesigning of production lines for new products. Though customers would prefer customised products, they abide by the mass production concept due to the price parameter. It AI and machine learning achieve and making manufacturing processes flexible allowing cheap customization, that would create a real shift in several markets. For example, instead of most shoes coming in a dozen sizes, they might be made in an infinite number of sizes, each order custom-fitted, built, and shipped within hours of the order being placed.

Healthcare and Biotechnology

Global potential of technology in life sciences

- Average life expectancy in OECD countries has increased by 5.5 years from 75 in 1990 to 80.5 years in 2015
- Telehealth/ e-health use is accelerating. By 2018, 65% of interactions with health care facilities will occur by mobile devices. Some 80% of doctors already use smartphones and medical apps in health care provision
- Global health care spending is estimated to grow at 4.2 per cent per year from $7.1 trillion in 2015 to $8.7 trillion by 20205 Global pharmaceutical spending will rise by 5% a year from 2017-2021, more than twice the average annual 2.2% rise during 2011 to 2016
- The market for precision medicine is expected to increase from $39 billion in 2015 to reach $87.7 billion by 2023
- Between 2010 and 2016 the average cost of bringing a drug to market increased by 33%, yet average peak sales decreased by 49%

According to EY predictions: the world in 2022, The quantified self means people are active participants in managing their own health and wellbeing. The following trends are being noted:

- There is now broad adoption of bio-sensing wearable devices (interoperable, integrated, engaging and outcomes-focussed) - the technology has become much cheaper and more sophisticated, and the quality of data has improved.
- New generation wearables continuously monitor a broad range of physiology, with service users supported to use the data to improve prevention.
- Wearables and connected devices are helping seniors age in place, alleviating, to an extent, the growing care gap.
- Interactive 'health app libraries' help people choose the most appropriate health apps and digital technologies and signpost individuals to a suite of approved digital health engagement tools.
- Voice technology is widely adopted, as people become more comfortable with secure, voice-based authentication services.
- Older people and those with dependencies are supported by virtual assistants to live more independently.
- Most people now expect to be offered telemedicine services, and many prefer first contact with a physician to be via telemedicine.
- People share their health data willingly with health providers, much like consumer data. • Gamification, using a system of incentives and rewards, helps influence healthier behaviours. • Patient groups have formed digital networks to support each other in managing their health, sharing best practices and lowering medical costs by tapping into the knowledge of the crow
- People accept that they are largely responsible for their own health; incentives for good behaviour are now firmly established – from reductions in co-payments to tax incentives (e.g. for not smoking).

- Payers and providers have created more patient centric care delivery models that involve increased collaboration and shared decision making.
- People can access real-time information about the performance and outcomes of providers, including how personal information is used and protected, improving trust.
- Payers and providers have developed reliable risk mitigation strategies that demonstrate the effective use, and prevent misuse, of personal information.
- Health apps and digital technologies are 'kite-marked' to demonstrate they meet global compliance standards.
- Regulators have been instrumental in supporting the use of telemedicine technology based on new, reliable digital tools, including medications management, with most payers offering a menu of reimbursement options and/or tariff payments.
- Clarity over the role of insurance companies and how they can use data has reduced concerns over data sharing, albeit a 'healthy' level of distrust remains.

Development potential in Mauritius beyond local needs

The healthcare sector in Mauritius has metamorphosed itself into an integrated cluster underpinned by a core group of high-value activities such as hi-tech medicine, medical tourism, medical education and wellness. With state-of-the-art medical facilities and highly qualified personnel, Mauritius is positioning itself to cater for the growing needs of both domestic and international patients.

Over the years, the number of private institutions has doubled, and future projections indicate that the sector is expected to substantially contribute to GDP and become a pillar of the economy. The presence of global healthcare players on the island has positively increased competition and enhanced the image of Mauritius as a high-tech medical hub.

Global healthcare companies have invested in multi-specialty and super-specialty centres of excellence to cater for the growing healthcare needs of both national and international patients. Furthermore, with a rising standard of living and longer life expectancies, the need for quality healthcare is of upmost importance for the locals also.

Key Facts	
Healthcare sector at a glance	GDP contribution: 4.4% Real GDP growth rate: 6.1% Total employment Approx.: 8500
Healthcare Infrastructure	More than 4,500 beds in both public and private sectors 5 major public hospitals 6 specialized public hospitals 18 private clinics 11 Speciality centres 28 private medical laboratories
Healthcare Personnel	20.2 doctors per 10,000 inhabitants 2.1 dentists per 10,000 inhabitants 3.1 pharmacists per 10,000 inhabitants 28.1 nurses per 10,000 inhabitants
Geriatric Facilities	37 Private Residential Care Homes 27 Residential Care Homes run by charitable institutions

Population Demographics	As at December 2016, the resident population was estimated at 1,221,150 As at December 2011, 43.9 % of the population was in the age group of 30 – 60 years (21.97 % male and 21.89 % female) Life expectancy for men is 71 years and for women 77.8 years
Medical Tourism	More than 18 000 patients in 2016 and 11 000 in 2017 Main source countries are: France, Madagascar, Seychelles

Table 3: Healthcare statistics

AI and Healthcare in Mauritius – the developmental roadmap

Healthcare Services

The demand for private healthcare services is growing at a sustained pace, driven mainly by an increasing expectation for more sophisticated and personalized private services and also broader private health insurance cover of the working population. There are opportunities for the setting up of multi-speciality and super-speciality hospitals to address the needs of the fast growing domestic healthcare sector

Medical Tourism

Over the last three years, medical tourism recorded a CAGR of more than 25%. In fact, medical tourism is one of the fastest growing sectors. To cater for the growing sector, there is a need to strengthen the healthcare infrastructure. Hence, there are attractive investment opportunities to respond to the needs of foreign patients travelling to Mauritius for treatment.

Collaborative Medical Research

The high prevalence of metabolic, lifestyle-related and cardiovascular diseases in Mauritius and countries of the region provide the right platform for conducting biomedical research. There is an opportunity for prestigious medical and research institutions to collaborate with local and regional partners to develop cutting-edge solutions to address the most threatening diseases in the region as well as in the world.

Laboratories & Diagnostic Centre

Many tourists and professionals optimize their trips to Mauritius to have a check-up and a thorough health screening. This creates opportunities for the setting up of medical laboratories and diagnostic centres. There are also opportunities for setting up of hi-tech medical imaging centres providing advanced diagnostics tools like radiography, tomography, magnetic resonance, thermography and nuclear medicine

Geriatrics

According to the UN, the world is currently facing the challenges of an ageing population. It is estimated that by 2050, the number of senior citizens in the world will exceed the number of young people for the first time in history. This trend clearly unveils opportunities in care for the elderly, geriatrics and rehabilitative medicine targeted to attend to the elderly coming to Mauritius for retirement or rehabilitative care.

Stem Cells Treatment

The country is making significant progress in the field of hi-tech medicine and is keeping pace with the world leaders in terms of latest advances in the field of medicine and biotechnology. There are opportunities to offer novel treatments such as autologous stem cell therapy to treat a broad spectrum of diseases including cancer, Parkinson's disease, spinal cord injuries, amyotrophic lateral sclerosis, multiple sclerosis, muscle damage and neurological disorders, amongst others.

Cosmetic and Reconstructive surgery

An increasing number of tourists travel to Mauritius to enjoy a tropical vacation together with an elective cosmetic surgery. In particular, hair restoration treatments have improved the reputation of the island's cosmetic capabilities. There are opportunities for plastic and cosmetic surgery clinics to provide a comprehensive range of procedures like blepharoplasty, rhinoplasty, mammoplasty, abdominoplasty, lipoplasty, otoplasty and nymphoplasty.

Dentistry

With the burgeoning dental travel market, there are opportunities for setting up of dental clinics offering dental procedures and treatment in various areas like endodontics, orthodontics, periodontics, prosthodontics, pediatric dentistry, geriatric dentistry, cosmetic dentistry, oral and maxillofacial surgery and dentofacial orthopedics. In addition, opportunities have opened up for dental laboratories involved in the design and manufacture of dental implants, crowns, bridges, dentures, orthodontic appliances and other dental accessories.

Wellness Centres and Health Resorts

Mauritius has a long history of traditional and alternative medicine. With health and wellness becoming an international trend, the island attracts each year a constantly increasing number of health-conscious tourists. The picturesque natural landscape and the green environment of Mauritius make it an attractive destination for wellness tourism. There are opportunities for the setting up of wellness centres and health resorts in areas such as thalassotherapy, hydrotherapy, Chinese traditional medicine, ayurveda and herbal medicine, amongst others.

e- health

Mauritius has developed a strong capacity in providing services in healthcare. Extension of these services on the region can be fueled by technology. Such may include e-dispensary, e-support to surgeries, e-training among others. Several companies like CAE through their i-stan already provide for telemetrically connected healthcare centres which allow for training or intervention assistance via technology.

Genomics and patient specific medicine

A gamut of possibilities will be enabled by leveraging on genome recognition and analysis to propose patient specific medicine and treatment. Beyond improving healthcare, this can only open doors for making Mauritius (through its specific genomic population)

Diabetes and cardiovascular diseases

25% of Mauritian adults suffer from diabetes and are prone to cardiovascular diseases. The sequences of genomic characteristics with disease prevalence within a highly hetereogeneous population offers the possibility of testing medications in Mauritius for these diseases and create a high level centre of excellence.

Sector	Technologies	Implementation sequence	Adoption	Comments
Medical Tourism	AI based technologies that: • Improved data acquisition and client service (chatbots, automated prioritization and allocation of doctors) • Technology to enhance wellbeing in terms of creating the appropriate environment (domotics – temperature, humidity, light control,…)	Short term (1- 2 years)	Acquisition of off the shelf technologies by hospitals, private clinics, retirement villages, etc.	Will enhance the quality of services and better the visibility of Mauritius as a high-end medical hub.
Laboratories & Diagnostic Centre	AI can today assist in pre and precise diagnostic. Such applications may include: • Chatbots Companies are using AI-chatbots with speech recognition capability to identify patterns in patient symptoms to form a potential diagnosis, prevent disease and/or recommend an appropriate course of action • Oncology Researchers are using deep learning to train algorithms to recognize cancerous tissue at a level comparable to trained physicians. • Pathology Pathology is the medical specialty that is concerned with the diagnosis of disease based on the laboratory analysis of bodily fluids such as blood and urine, as well as tissues. Machine vision and other machine learning technologies can enhance the efforts traditionally left only to pathologists with microscopes. • Rare Diseases Facial recognition software is being combined with machine learning to help clinicians diagnose rare diseases. Patient photos are analyzed using facial analysis and deep learning to detect phenotypes that correlate with rare genetic diseases.	Medium and long term (3-5 years and more than 5 years)	Specialised laboratories, hospitals, private clinics	This will provide support to existing treatment centre, improve diagnostic capacity and enable data capture for further research needs.
Geriatrics	Support to elderly care by AI powered robots is opening a new economic avenue. Currently commercialized products are mainly focused on cognitive computing and machine learning to add capabilities to robotic assistants and companions for elderly care. Future applications include deep learning, machine learning and computer vision for human pose estimation, learning user behavior patterns and proactive activity suggestions targeted toward mental and physical health of elderly individuals. Several applications by Accenture, Hasbro, GE, etc. already exist.	Medium and long term (3-5 years and more than 5 years)	Smart cities, clinics and hospitals, retired villages	

Stem Cells Treatment	Efforts are being launched to use artificial intelligence (AI) to accumulate experiences of researchers who handle iPS cells and standardize them. This approach has the potential to ensure quality of mass-produced transplantable cells and to facilitate their distribution to more people, leading to the delivery of custom-made regenerative treatment for each patient in need at much lower cost.	Long term	Research centre and CROs	With its Regulatory Sandbox Licence, Mauritius can attract companies specializes in regenerative medicine namely to analyse their efficiency on such pathologies caused by diabetes
Cosmetic and Reconstructive surgery	• Burn care: AI can correctly assess the complete surface of the burnt skin, which the most important thing in order to give a patient the proper treatment. Next, it is able to predict whether the surgery is necessary or the skin will be able to heal on its own. More precisely, a study on reflectance spectrometry and artificial neural networks showed that the AI accuracy was up to 86%, hardly achievable with using just a naked eye. • Hand transplant As hands are very complex parts of our body, AI is the perfect tool for designing automated controllers in cases where patients need neuroprostheses. As hands are highly sophisticated, these neuroprostheses have to be highly accurate, and AI devices allow engineers and surgeons to collect valuable data in order to provide patients with better prosthetics. • Skin cancer AI is able able to detect skin cancer much earlier than a dermatologist. Its ability to detect cancer just from photos has come so far that there are even apps on smartphones for checking for cancer. Actually, some studies have shown that AI not only detects cancer more accurately, but it also classifies it in a far more precise way.	Medium and long term	Adoption by specialty health centres, hospitals, clinic, CROs, specialized laboratories etc.	Provide for cutting edge treatment in a field well sought after by foreigners in Mauritius.
Dentistry	• Radiology: Artificial intelligence and machine learning technologies offer care providers an opportunity to accelerate radiology processes and more easily process the large quantities of data generated through digital images. • Ability to determine most efficient treatment through a complex recognition of results by analysis such criteria like damage, general gum quality, age of client etc. (e.g. To choose between a denture vs implants)	Medium term	Dentists and dental clinics	
e- health	• Distance surgical, diagnostic and treatment through AI and telemetric supported tools (tools like Istan from CAE enabled medical training and treatment on dummy patients and all	Short to medium term	Hospitals, clinics, research centres, BPO companies	This will enable companies and doctors to extend their services to the region.

	sensorial inputs and outputs can be monitored locally and from remote areas) • Specialised centre with high neural network capacity can be used to assist doctors worldwide in surgical and medical decisions. • Domotics enables patients to be connected to sensorial straps that relate online health information to servers and doctors such that assistance can be obtained at distance as and when required.			
Genomics and patient specific medicine	Genomics is closely related to Precision medicine. With a market size projected to reach $87 billion by 2023, the field of Precision Medicine (also known as personalized medicine) is an approach to patient care that encompasses genetics, behaviors and environment with a goal of implementing a s\ AI applications are available to correlate DNA sequences and computer modelled changes to interpret the effect of medications on specific DNA arrangements.	Medium to long term	Adoption by specialty health centres, hospitals, clinic, CROs, specialized laboratories etc.	Opens new opportunities for research and testing of high end pharmaceutical products.
Diabetes and cardiovascular diseases	Artificial intelligence provides interesting scopes for research, improvement and treatment and patient management of victims of diabetes and cardiovascular diseases. The prevalence of such diseases being frequent in the Mauritian population and the latter bearing a diversified genetic representation makes Mauritius an ideal place for testing and fine tuning of these applications and improving treatment for these diseases. AI applications in this line include: • Insulin Bolus Calculators and Advisory Systems • Risk and Patient Stratification • Lifestyle and Daily-Life Support in Diabetes Management • Detection of Adverse Glycemic Events • Surgery assistance for cardio transplants • Pressure modeling	Medium to long term	Adoption by specialty health centres, hospitals, clinic, CROs, specialized laboratories etc.	Build capacity
Biotechnology	Biotechnology can be classified as white, red, green and blue biotechnology. Red and white biotechnology have already been covered in the previous sections. Mauritius further has an immense potential to develop a blue and green biotechnology industry. Mauritius comprises of a rich land-based fauna and flora with evidentially supported pharmaco, cosmetic and nutraceutical active elements. AI has a huge potential in structuring an exhaustive database of the active compounds and relate	Medium to long term	Adoption by specialty health centres, hospitals, clinic, CROs, specialized laboratorial, major pharmaceutical companies, research centres, etc.	

	their effects on different and specific population sample. In addition, Mauritius boost a 2.3 million km^2 EEZ with rich marine biodiversity comprising of active compounds.			

Table 5 Potential applications of AI

Cost of AI applications in Healthcare and Biotech

Artificial intelligence projects (development and/or adoption) can be classified into several phases and the inherent costs vary accordingly:

- Discovery & Analysis Phase (>25 000 USD)
- Prototype Implementation and Evaluation Phase (50 000 USD)
- Minimum Viable Product (MVP) - Application for product design and commercialization
- Product release/ product implementation (25 000 USD - > 1 M USD)

Recommendations for timely and efficient adoption of AI in Healthcare and AI

- Review and increase the capacity of the existing ethics committees
- Institute pilot projects for patient data management at national level
- Develop databases of patients (upon agreement) to be able to test AI applications namely for deep genomic, DNA sequences, patient specific medicine, etc.
- Develop a database of compounds present in Mauritius to be able to test AI applications.
- Propose strong fiscal incentives and financial support to acquire technologies that will unroll e-health initiatives.

Fintech

Most AI applications do not have a physical form, but rather "live" in lines of code. The term "AI" includes all technology used to mimic human intelligence, typically falling into one of three subcategories: machine learning, natural language process and cognitive computing.

Currently, there are more than 2,000 AI start-ups in 70 countries that have raised more than $27 billion, according to Venture Scanner, a tech-centric analytics firm.

Fintech being itself a new industry leveraging on technology to grow and render financial services borderless, this sector is leading the way when it comes to both creation and adoption of AI – from managing assets to safeguarding against theft. In furtherance, quick and efficient adoption of AI will certainly catalyse the emergence of a strong and competitive Fintech industry.

According to the 'Fintech and Investor Communications', AI and machine learning will lead innovation in Fintech both in the short and medium term.

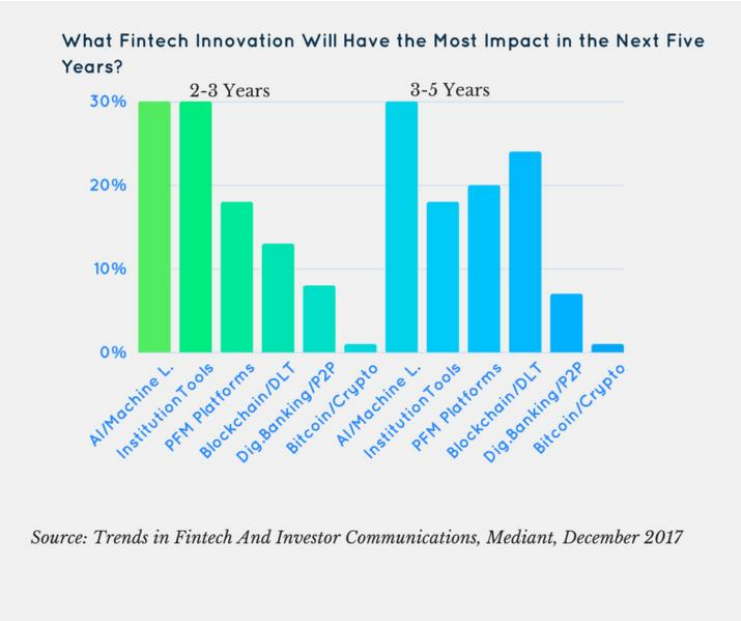


Figure 5 Expected impact of AI on FIntech

The Global potential

According to actual trends, AI in Fintech Market will be worth 7,305.6 million USD by 2022 with software tools solution expected to be the largest contributor in the global AI in Fintech market during the forecast period.

The greatest markers are expected to be North America followed by Asia. However, with a low banking and insurance penetration in Africa and an expected middle-income population emergence in Africa, the growth of AI driven fintech applications in Africa will be very significant.

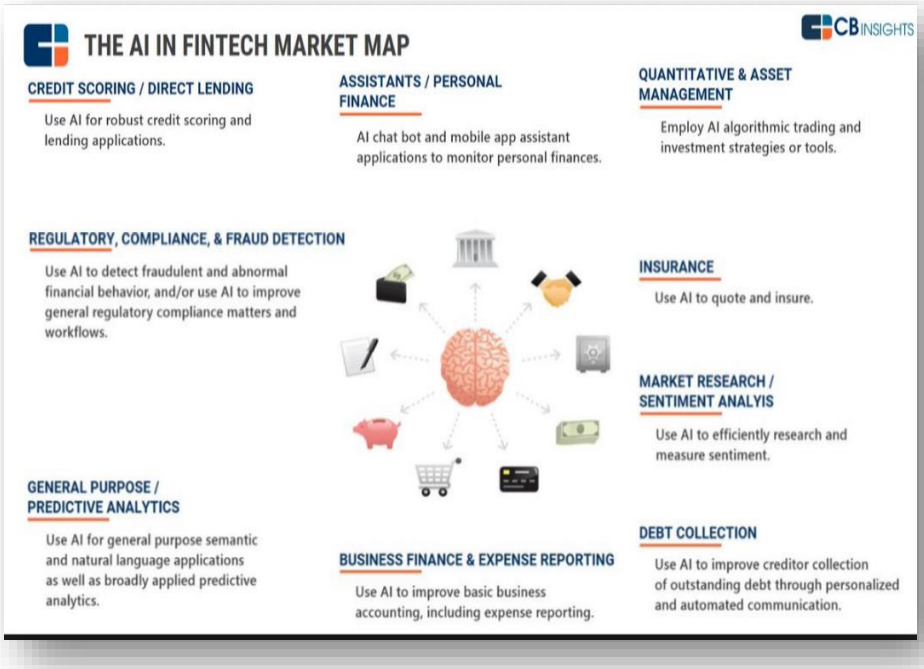


Figure 6 AI and Fintech

The Mauritian Fintech Potential

Mauritius has already engaged in the Fintech revolution. Backed by strong institutions, a booming financial industry and enabling Information, Communication and Technology infrastructures, Mauritius is positioning itself as an upcoming regional Fintech hub.

Companies are already engaged, at different degrees of maturity, in the following activities:

- Mobile payment
- E-banking
- Cross border clearances
- Digitization of platform
- Robot Advisory
- Business intelligence
- Wealth management
- Trade finance

Today startups represent 35% of the ICT industry, which comprises of some 850 companies. They employ 1 to 9 people each. 8% are engaged in the development of Fintech related activities (around 100 people). Around 47% of the ICT/BPO industry are actively engaged in provision of ITO services out of which nearly 13% are developing Fintech-related mobile applications and platforms

All of the above activities can further be fueled with AI applications

The Mauritian Fintech Potential – Africa

Mauritius has a relatively small internal market. However, financial services and Fintech applications go beyond border and the ability to capture markets is based on the aptitude of the financial centre to

propose clear advantages in terms of robustness, transparency, competitiveness, know-how, state of the art technologies and technology adoption and application.

With several Double Taxation Agreements and Investment Promotion and Protection Agreements with African countries, strong repute and quality services, Mauritius is a key financial centre for Africa and by default the centre of excellence for Fintech development for the region.

Already FDI inflows in Africa (excl. Global Business) from Mauritius account to USD 530 million for the last 5 years and private equity investments in Africa through the Mauritius IFC accounts to USD 106 million.

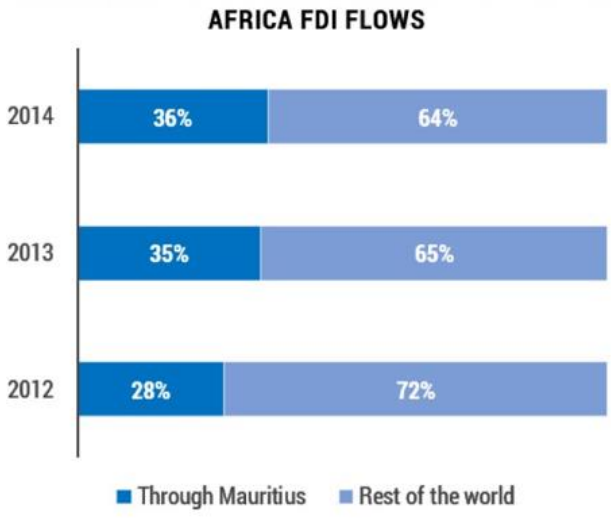
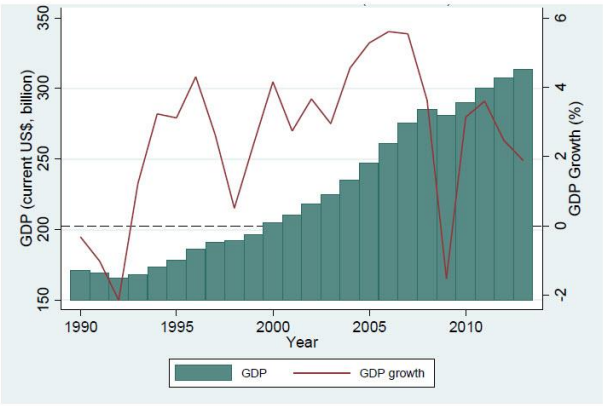


Figure 6 Africa FDI flows through Mauritius

Size of the African market

- Africa has as many cities of 1 million people as North America or Europe and by 2025 the working population of Africa is expected to overtake China.
- By 2030 Africa's 18 mega cities are expected to have combined consumer spending of around $1.3trn volume of trade between Africa and China rose from $9bn in 2000 to $210 bn in 2012.
- South to South trade in goods will double by 2030, within that trade in services will have quadrupled in the same time, and globally the value of trade in services will soar from $1.6 trillion to $8 trillion between 2012 and 2030.
- Full fledge penetration of banking and insurance is low (less than 10%) and with large population living in remote rural areas, Fintech will be a key enabler to enable access to financial services and insurance.



Source: World Bank (2015); own graph.

Figure 7 Africa GDP

The first mover advantage of Mauritius in becoming a technology hub for Africa

The first mover advantage is not usually a single advantage, but rather a set of advantages, which a company, an institution or a country obtains by being the first to develop and market a product. Being first enables the entity to obtain many prime advantages that strengthen its position in the marketplace. For example, a first mover often gains exclusive agreements with suppliers and clients, sets industry standards, develops strong relationships with retailers, creates brand name recognition and unrolls the business to ensure its success.

Mauritius has been successful in several initiatives by being a first mover such as in the textile industry by putting the right framework, the ICT sector by ensuring adequate infrastructure and workforce, the port sector, among others.

Mauritius has also been a regional pioneer to create the adequate framework (regulatory, capacity building, network, infrastructure, institutions, incentives) to become a leader in the world of Fintech driven by such technologies like AI.

Mauritius is however, not the only hub contemplating the amazing market of Fintech. It will be essential for Mauritius to ensure swift technology adoption such as AI to foster efficiency and capacity in its Fintech venture. For instance, we note in the figure below that several countries are providing regulatory support for development of Fintech. Beyond these countries like Rwanda, South Africa, Dubai, Malaysia are clear competitors to Mauritius. Furthermore, Fintech being borderless, technology adoption, capacity building, infrastructural development is far more important than geographic positioning that usual is of importance in several other sectors.

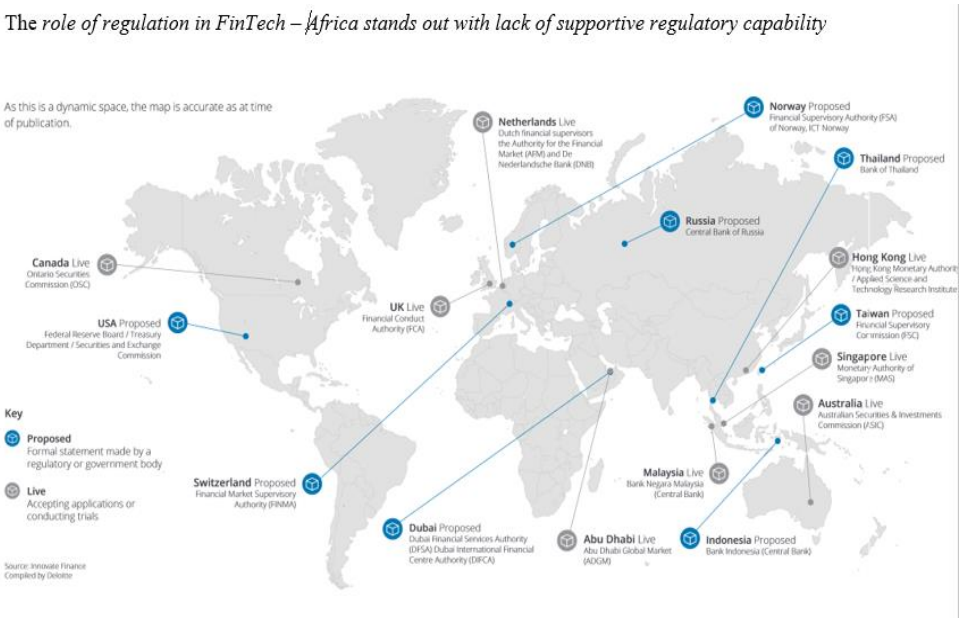


Figure 8: Countries with strong regulatory capacity for Fintech

The table below provides for a set of incentives/ measures, their actual status and impact on Fintech and the additional requirements to ensure achieving full potential of the sector.

Measure/ Incentive	Detail	Status	Comments/ improvements
Year 2015 – Diaspora Scheme	Provides for several fiscal incentives to attract high profile Mauritian diaspora to Mauritius.	Some 5 diaspora scheme recipients are involved in Blockchain, robo-advisory and e-FX	The scheme should have better visibility and the thresholds revised to capture more techno- preneurs
Year 2016 Regulatory Sandbox Licence	Allows for drafting a tailor made, project specific 'piece of law' in case that an innovative project is not fully regulated	68 projects received mostly in the Fintech space.	All other existing licences/ permits should be streamlined
Year 2016 – Fiscal incentives for R&D expenditures	Allows for fiscal deduction for expenses in R&D		Will require more visibility
Year 2016 – national incubator scheme	Government providing for a matching grant for all expenses incurred with incubatees within accredited incubators.	Several approved incubators and dynamic incubatees	
Year 2016- Mauritius Research Council becoming the Mauritius Research and Innovation Council	Several grant schemes structured (POIGS, Innovation bridge, CRIGS,…) all devised to encourage private sector participation by leveraging on matching grants	All schemes are operational	Need to ensure greater participation
Year 2017 – Innovator's permit	Allows for innovators to obtain an occupation permit at reduced investment threshold (USD 40k instead of USD 100 k)	2 Innovators OP have been issued	May need to be further reduced to capture more innovation nomads

Year 2017 – Innovation box	Allows for an 8 years tax holiday on all revenues from IP derived revenues	No one has claimed the benefits so far	Will need strength the IP framework and ensure greater visibility
Year 2018 – Fintech association	Government providing seed capital to structure a regional Fintech association with international experts	The Association will be running by November 2018 and will foster on : - Attracting major companies in financial technologies - Building capacity to foster export of services in Fintech - Create start-ups - Ensure networking	

Beyond previously mentioned, several measures/ incentives and efforts have been put forward to position Mauritius as the regional Fintech hub:

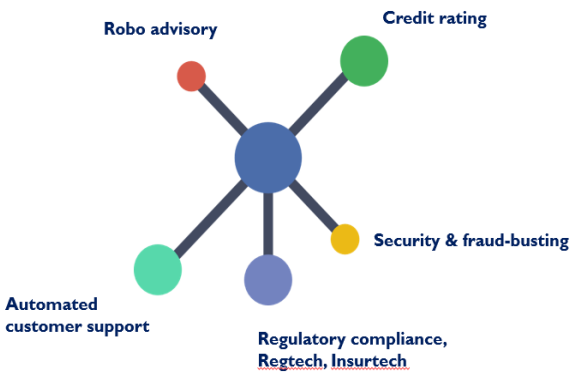
- 2016: Blockchain conference (EDB)
- 2017: Fintech conference - EDB
- Stock exchange enabling: Multi-currency stock exchange
- International Arbitration centre
- Taxation and investment protection agreement
- Robust and aggressive banking sector

Powered by AI to capture greater markets

Fintech can be viewed as an extension of Financial services by the use of technology. For example, Blockchain makes use of electronic ledgers on a digital platform which is decentralized to enable transfer of assets (digital) and this has, by extension, instituted the concept of cryptocurrencies.

Technology such as AI can enable a gamut of cheaper, more efficient, online financial services such as robo-advisors, automatic P2P platforms, compliance automation, etc.

In this chapter we will propose some examples of applications of AI in Fintech for which Mauritius has first mover advantage both for technology adoption and internal market applications as well as service development and exports.



Opportunities

- Improved speed of operations
- Streamlining processes
- Big data management and precision decision taking
- Reduced cost of operation

Impacts

- Coding error
- Non-compliance with lending or other financial laws
- Violation of data protection laws
- Cost of training of employees

Figure 9: Sectors of relevance to Mauritius, opportunities and their impact on the financial and fintech sector

Robo-advisory

A self-guided online wealth management service that provides automated investment advice at low costs and low account minimums, employing portfolio management algorithms.

Adoption: Banks, wealth managers, insurance firms and other professional players

Implementation timeframe: Medium term (3-5 years)

- Identify problem statements in companies
- Gathering intelligence on market and their needs
- Soft short-term training and long-term training
- Incentives for quick adoption
- Enabling linkage with academia and incubator labs to export services

Opportunities:

- Precision decision taking
- Reduced cost of operation
- 24/7 services
- Participation of wider audience
- Reduced costs of operations

Threats:

- Redundancies
- Coding error
- Non-linear events

Security and Fraud busting

Improve defenses with the ability to detect threats in real time and accurately predict emerging threats that are not detectable by humans

Adoption: Banks, insurance firms, management companies

Implementation timeframe: Long term (5 years onwards)

- Identify problem statements in companies
- National project with banks and financial institutions
- Gathering intelligence on market and their needs
- Soft short term training and long term training
- Incentives for quick adoption
- Enabling linkage with academia and incubator labs to export services

Opportunities

- Precision decision taking
- Reduced cost of operation
- 24/7 services

Threats

- Redundancies
- Data protection and GDPR

- Coding errors
- Non-linear AML/KYC

Customer Service redefined

Such activities aiming at automated customer support include inter-alia: chatbots, Algorithmic Business Intelligence, Smart automated reporting, etc.

The finance sector can leverage AI technology to cut **22% of operating costs** - totaling a staggering **$1 trillion.** Adoptors may include banks, hotels, Governmental institutions, among others.

Implementation timeframe: Short term (1-3 years)

- Identify problem statements in companies
- National projects aiming at efficiency

Opportunities

- Better customer experience
- Reduced cost of operation
- 24/7 services
- Increased financial literacy
- Online and continuous business/ account performance monitoring

Impacts

- Redundancies
- Low financial and technological literacy
- Language recognition
- Coding errors
- Non-linear AML/KYC

Credit rating and loan management

Such activities include, inter-alia, Lending and loan management software, Algorithmic Business Intelligence, Smart automated reporting, etc. Adoptors may include Banks, lending institutions and other financial institutions.

Implementation timeframe: Long term (5 years and beyond)

- Identify problem statements in companies
- National project with banks and financial institutions
- Gathering intelligence on market and their needs
- Soft short term training and long term training
- Incentives for quick adoption
- Enabling linkage with academia and incubator labs to export services

Opportunities

- Streamlined processes
- Reduced cost of operation
- 24/7 services
- No discretion – Rules base

- Integrates in crowdlending platforms and allows for project quality monitoring

Impacts

- Informatic errors
- Data management issues
- Coding or modeling errors
- Data protection and GDPR
- Redundancies

Regulatory compliance, RegTech, InsurTech

Such activities include inter-alia, Complex RegTech systems, Algorithmic text analysis, Smart contract issuance, etc. Adopters may include Banks, lending institutions and other financial institutions.

Implementation timeframe: Long term (5 years and beyond)

- Identify problem statements in companies
- National project with banks and financial institutions
- Gathering intelligence on market and their needs
- Soft short-term training and long term training
- Incentives for quick adoption
- Enabling linkage with academia and incubator labs to export services

Opportunities

- Better customer experience
- Reduced cost of operation
- 24/7 services
- Increased financial literacy
- Global compliance and continuous monitoring
- Borderless market

Threats

- Highly trained personnel
- Regulatory risks
- Coding or modeling errors

Cost of AI applications in Fintech

Artificial intelligence projects (development and/or adoption) can be classified into several phases and the inherent costs vary accordingly:

- Discovery & Analysis Phase (10 000 USD)
- Prototype Implementation and Evaluation Phase (25 000 USD)
- Minimum Viable Product (MVP) - Application for product design and commercialization
- Product release/ product implementation (15 000 USD - > 1 M USD)

The below graphical representation provides for an outline of the relative cost of applications and their potential implementation timeframe. The size of the circles gives an indication of the complexity of the ecosystem (technology and trained workforce) that may be required.

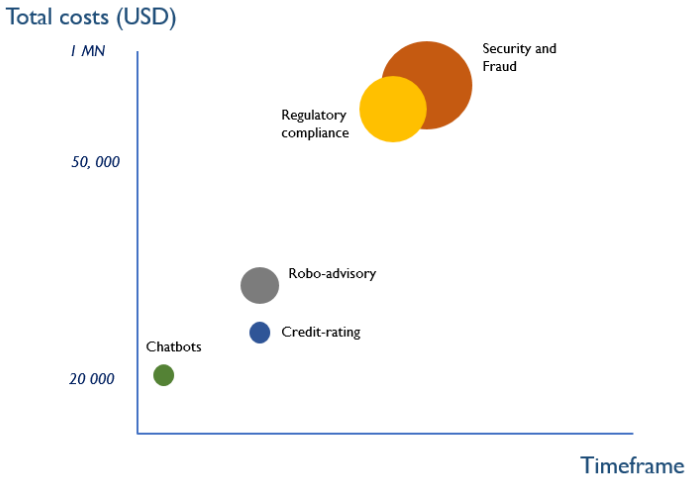


Figure 10: AI in Fintech – cost, implementation timeframe and complexity

Recommendations for timely and efficient adoption of AI in Fintech

- The regulatory framework should be rendered more streamlined and provide for certainty in the Fintech space:
    - Timeframe for opening a bank account;
    - Obtaining an e-wallet license
    - Among others.
- Support Intellectual property protection namely by adoption the IP bill in parliament and signing international protocols such as the madrid, PCT and the Hague.
- Supporting compliance with international data sharing codes to enable harnessing of global data.
- Providing for a double deduction on R&D expenses for AI development and adoption in Fintech namely for banks and financial institutions
- Supporting networking with international players in this space.
- Scholarships where youngsters are given international exposure by following training courses abroad.

Agriculture

Rationale for AI

Agriculture is seeing rapid adoption of Artificial Intelligence (AI) and Machine Learning (ML) both in terms of agricultural products and in-field farming techniques. The application of Artificial Intelligence (AI) to the problems of agriculture will be critical in the near future. The most challenging problem facing agriculture, in general, is the shrinking labour force combined with expanding production and distribution requirements needed to feed the planet and grow local economies. The population of farmers is shrinking. Fewer young people are choosing to plant and grow crops in the traditional manner. This poses a threat to the Mauritian economy.

The most sustainable solution to the challenges of a shrinking labour force and need for continued production growth is automation at various stages of production. In addition to automation in general, there is a move to use different sensors together with AI decision-making to make automation "smart". This can be accomplished by AI systems capable of making human-like decisions that may ultimately limit the use of harmful chemical pesticides/herbicides and diagnose and treat plants and animals individually. Because most of the required sensors are inexpensive and computer power is affordable it is possible to use them together with AI to more efficiently fertilize, irrigate, diagnose and treat crops and animals on a case-by-case basis. Tracking individual organisms provides the capability of early detection of health problems that may threaten yields. AI systems are capable of using neural networks to classify inputs and give high quality outputs leading to predictions that allow farmers and scientists to generate models that forecast yields or optimize efficiency of production.

Major AI techniques in agriculture:

Expert Systems, Artificial Neural Networks and Fuzzy systems, hybrid systems such as neuro-fuzzy or image processing coupled with artificial neural networks.

AI applications:

- Crop Management, crop protection systems
- Pest management: systems that identify active pests and suggest control measures
- Disease management
- Weed management: minimize herbicide application
- Yield prediction: various machine learning analytical models help farmers to predict the impact of various environment factors on crop yield. Farmers can forecast weather conditions and accordingly take corrective measures.

Potential applications of AI in the Mauritian context

Precision Farming – "Right Place, Right Time, Right Product"

AI provides a more accurate and controlled technique that replaces the repetitive and labour-intensive part of farming. It also provides guidance about crop rotation, optimum planting and harvesting time, water management, nutrient management and pest attacks. Precision farming helps in increasing profitability by identifying crops and market strategically. It enables overall accuracy and efficient use of resources. Through precision farming management identification of stress level in a plant can be obtained from high-resolution images and multiple sensor data on plants.

Harvesting

Computer vision for auto picking of fruits and vegetables, when decisions have to be made about which strawberries are ripe and ready to pick. An automated picker uses a neural network AI and decision tree system that replaces dozens of manual human harvesters.

Crop Monitoring & Health Assessment

Multispectral imaging via drones or surveillance cameras to measure the health of crops and detect pathogens or disease in areas that can be treated before it becomes a problem. Tracking individual organisms provides the capability of early detection of health problems that may threaten yields.AI systems integrate these inputs with other datasets to generate predictions and better models.

Weed and pest detection and elimination

Computer vision coupled with drones for weed and pest detection and elimination using micro spraying individual weeds/pests with an automated robotic sprayer or laser system for destroying pests or weeds.

Monitor crop health and soil properties

Wireless transmission from remote sensors that monitor crop health and soil properties. The AI system integrates sensor data from remote sensors and combines it with climate models and other information to generate predictions after the system has been sufficiently trained.

Drone assisted Air sampling

Drone assisted Air sampling sensors capable of detecting aerosolized spores and other chemical agents that allow analysis of potential mycotoxigenic molds or harmful chemical overspray or genetic drift. AI mapping can lead to better predictions about where outbreaks may initiate and where treatment strategies need to be directed

Movement of individual chickens or livestock

Use of computer vision imaging to detect movement of individual chickens or livestock, like particles detected by a Neural Network AI system to make predictions about whether a cow is in heat or if the animals are sick.

Thermal imaging of livestock body temperature

Thermal imaging of livestock body temperature or udders to detect pre symptomatic mastitis so the animal can be treated before the infection has a costly effect on productivity. Temperature sensor data is provided as input to AI neural networks or statistical decision trees to make predictions.

Yield prediction or growth tracking

Multi-lens or perspective 3D imaging that can measure weight and size of livestock or crops in order to feed as inputs into AI systems to predict yields or track growth over time.

Identification of disease

Auditory monitoring coupled with Neural Network AI of livestock, like pigs to detect coughs or sneezes to identify animals that are sick or contagious. The AI system functions to separate harmless sounds from those that might pose a threat, like an illness.

Classify pests, birds, bats and predators

Auditory monitoring of crops to detect and classify pests, birds, bats and predators that may be operating at night. The AI system functions to identify specific types of sounds associated with specific organisms and their known behaviors.

Companies involved in AI for agricultural applications

Intello labs (India) use deep learning algorithms for image analysis. Using this technology, farmers can check health of their crop at different stage of its growth. For instance, using their mobile phone app, the tomato farmer could take a picture of a bushel of tomatoes and upload it into Intello's system. The company's algorithms would examine the photo of the tomatoes and gives it a rating based on a set of government (i.e. USDA) or other criteria. With this objective, algorithmic rating in place, each party in the negotiation now knows the quality of the tomatoes being sold, thus providing quality grading to different food products.

PEAT (Berlin based agricultural startup) developed Plantix, an application based on deep learning algorithm to identify defects in crops and soil health.

Microsoft in collaboration with United Phosphorous developed Pest Risk Protection to help farmers with advance information about pest attacks. Microsoft has developed an AI based Sowing app that forecast the right time to sow crops as per the climatic conditions. Farmers using this app get text or voice message to guide the farmers about the right time for sowing of crops.

To overcome herbicide resistance, Blue River Technology developed an agricultural robot to ensure weed control and protect crops. A robot called See and Spray using automation and Computer vision spray weeds on cotton precisely and prevent herbicide resistance.

CropIn and Robert Bosch Engineering and Business solutions provide a range of technologies based on AI in areas such as pest surveillance, climate control, controlled irrigation and warehouse management.

Way forward

The first necessary stage to implement any of the above concrete examples of AI in agriculture is gathering sensor data in an efficient and inexpensive automated manner that can provide sensitive imaging, sound, chemical and biological information to train the AI system. Not only will AI assist with automation to help solve the problem of a shrinking labor force but it will also help mitigate problems associated with climate change, such as drought and disease and anthropogenic pollution or other environmental assaults.

The promotion of precision agriculture, smart irrigation, remote sensing technology, drone applications and cold storage solutions that rely on AI and IoT accessible both through web and mobile applications should boost tremendously the agricultural sector in Mauritius. Overall, the emerging field of AI has the benefit of engaging young entrepreneurs to help solve the growing problems in agriculture for Mauritius.

The UoM is developing an Agri-Tech Park and one of its identified thrust is digital farming. The University proposes to spearhead the proposed applications of AI in agriculture in close collaboration

with all stakeholders from the public and parastatals organisations and private companies through a digital farming cluster. Two concrete proposals for AI applications are:

Proposal #1: fruit bat monitoring and damage incidence on our local fruits

Auditory monitoring of birds, bats and other predators can be effected by making use of drone technology. More so, infrared cameras can supplement the auditory monitoring of pest noise and confirm fruit bat population in major production areas of the island. An **AI** system can be developed to capture the data from the sensors, cameras and auditory devices to understand behaviors of pest organisms. Specific types of sounds and their frequencies can be interpreted and information arising thereof can be used to alert authorities about the regions where bat infestation is higher, which can call for corrective mechanisms like the use of ultra-sound devices to repel bats and application of bird nets (expensive to buy and lay!) to protect our harvest.

Proposal #2: Onion production

There are around 600 farmers, who cultivate around 500 arpents of land that yield 2000 tonnes of onions annually, this farmer's cooperative faces a number of agronomic hurdles. In particular, seawater infiltration in the coastal areas. Infiltration of seawater increases soil salinity and alkalinity, alters soil pH, which negatively impact on the absorption of soil nutrients by plants. Yield can be severely affected. Soil sensors are available (developed by Decagon Services, US) that can measure these parameters and feed them to data loggers or other data capture devices (e.g. on drones).

These data may be utilised by AI systems, with minimal human intervention, to effect corrective mechanisms like water flushing systems that will wash out salt accumulations away from the onion production zones. An alert system can also be set up to inform the farmers and authorities of the Belle Mare region of any additional corrective measures.

Thrips and leaf miners are pests that severely infest the onion crops. Pest infestation by leaf miners can be easily detected via development of serpentine tunnels on the onion leaf by the naked eye. Computer imaging systems, along with drone technology can detect these pests reliably. Moreover, multispectral imaging via surveillance cameras can yield valuable information on the health status of crops, well before the pests developed as epidemics.

The idea behind such detection system is that it does not depend on the poor know-how of farmers on pest identification and also it is done irrespective of climate and time availability (farmers often lack time for pest surveillance and they end up doing preventive spraying, causing unnecessary damage to the environment).

Based on the monitoring of soil properties and crop health status data, wireless transmission from remote sensors can be also developed to feed the AI system. This AI system shall integrate the sensor data and combines them with climate models and other information to generate effective predictions, for the benefit of farmers without much involving them and extension workers.

Ocean economy

Boasting a 2.3 million km^2 Exclusive Economic Zone (EEZ), Mauritius' Ocean Economy represents over 10.3 % of the national GDP of Mauritius. The Government ambitions to double the contribution of the Ocean Economy to GDP in the medium term.

Under the background of global ocean development, artificial intelligence has increasing importance which urges the improvement of traditional research and exploration methods which are key enablers to unlock the full potential of the Ocean Economy.

Marine applications of artificial intelligence can be classified according to the different segments that make part of the Mauritian Ocean Economy namely: Fisheries and seafood, Port and Port Services, Marine Biotechnology, Marine Renewable Energy, Oil, gas and mineral Exploration and Exploitation, Marine Services, Marine ICT, Logistics and marine security.

Ocean development is a common focus of global attention especially with its potential of spuring new development in pharmaceutical industry and mining industry through the discovery of active compounds and mineral/ hydrocarbon rich reserves. Technology is a key enabler in unlocking and harnessing the full potential of the blue economy namely by enabling DNA sequencing, maritime security and intelligence, fish and non-fish resource assessment and modeling and non-living resource management and business intelligence modeling.

Ocean technology will be mainly geared towards extensive use of the internet of things, i.e., connectivity of different sensors with an aim to create big data. Artificial Intelligence will be key in interpreting and correlating these big data with system optimization and building clear business strategies.

Applications of AI in Mauritius

Maritime internet of things

As an important part of the new information age, "Internet of things" has become the key areas of AI integrated application. However, the "Internet of things" currently still exist poor properties, limited application, safety risks and some other problems. As the emerging trend of "Internet of things" development, "maritime Internet of things" grows rapidly, and gradually extends from inland and coastal waters to the ocean, leading the "Internet of things" overall development.

Applications include, inter alia:

- Use of sensors and data acquisition systems to monitor rise in water levels and sand erosion;
- Use of sensors and data acquisition to follow migratory resources and the related impact of climate change;
- Tracking of endangered specifies;
- Tracking of vessels for logistics optimization and ensure maritime security

Unlocking the blue biotechnology

The ocean is rich with an immense untapped pool of organisms with pharmaceutically active compounds. Artificial Intelligence will be a key enabler in managing huge databases of these organisms, their compounds and their effects on different modeled genomic structures to move into a new era of precision medicine.

Already several applications are being tested. Furthermore, complex neural network foundations have the capacity of doing first level predicted pre-clinical impacts enabling the reduction of the number of tests to be done prior to maturing the pharmaceutical venture.

Smart Port Concept

The port is a key sector of the Ocean Economy. All the different activities are closely linked

Maritime Efficiency

As the "Maritime Internet of Things" developed rapidly in such countries like Denmark, USA and China, the basic frame of world's largest "Maritime Internet of Things"—China shipping automatic identification system (AIS) network has covered almost all coastal waters and advanced course above inland waterway's four level, and all the 264 base stations and AIS national data center achieve interoperability. Meanwhile, through ship-borne equipment and shore-based networking system, it is possible to realize mutual recognition and information exchange of ship-ship and ship-shore, which further improve navigation efficiency and reduce accident probability, making the comprehensive benefit amount to $ 12 billion.

At present, as the third regional center system of global AIS shore-based network, China AIS system has realized data exchange with Denmark, South Korea and other countries.

Wisdom Navigation

The importance of navigation in the ocean economy is to be highlighted. Regarded as the world economic barometer, navigation recovers more than 90% of the global trade, and its technologies have become indispensable key means of defending national marine rights and interests. However, the information technology equipment of navigation is very popular currently, demands of more intensive global navigation networks are still not meted in ocean century.

Therefore, relying on the maritime Internet of things, AI ships and other key technologies, it is of great significance to promote the navigation industry transfers from the traditional navigation to electronic navigation (E-NAV), then the intelligent navigation (I-NAV).

Compared with the electronic navigation, intelligent navigation mainly has the following advantages:

- firstly, the interactive communication of ships, beacons and shore ensures the high-density navigation safety;
- secondly, the implementation of autonomous navigation and collision avoidance reduces manmade accident;
- thirdly, active analysis and warning for objects on sea improve the ship security ability;
- fourthly, it is possible to conduct robot rescue under extreme environments;
- fifthly, dynamic monitoring of ships' anti-pollution can be done.

In recent years, intelligent navigation has achieved breakthrough development, take China for an example, intelligent search and rescue system, automatic collision avoidance systems, digital ports and three- dimensional ocean charts are orderly conducted and "digital navigation mark" has begun to take shape**.**

Deep sea exploration

Under with the ocean development expansion continually from the shallow waters to the far-reaching sea, the "Integrated Ocean Drilling", "Sea Floor Observatory Network" and other far-reaching sea global projects are carried out. Because of the complicated environment in far- reaching sea, detection technology equipments are facing great challenge. In this case, far-reaching sea exploration submersible especially unmanned detector (i.e., far-reaching sea exploration robot) has gradually become the main

base of far-reaching sea exploration. Therefore, AI technologies that satisfy the specific exploration robot and exploration environment become one of the research focuses. It is being noticed that independent judgment and reasoning and other thinking abilities of intelligent robots have improved greatly, which make it possible that the intelligence programs can not only receipt and feedback environment information in high quality way, but also be able to complete difficult and delicate movement based on comprehensive environment. At present, the far-reaching sea exploration robots mainly consist of two types: Remote Operated Vehicle (ROV) and Autonomous Underwater Vehicle(AUV).

Digital Ocean Towards Intelligence

At present, the main maritime countries have poured much resource into the construction of "digital ocean" system. For example, the "Neptune" plan of United States and Canada; ARANA program of Japan has initially completed, 25 African coastal countries also jointly set up the African offshore resource data and network information platform. However, due to the strong dynamics, extensive synthesis and large quantities data and other characteristics of marine information, forecast and preview are faced with a number of challenges. Therefore, the deep combination of AI, information technology and remote sensing to improve the capacity of system analysis and stimulation has become an important trend.

Transport

State of play & Challenges

The transport problem in Mauritius has grown into a serious one as more and more people resort to the use of a personal means of transport. Over the past thirty years, the number of vehicles on our roads has increased by almost 400%, making Mauritius one of the densest countries in terms of traffic management. Statistics reveal that for a population of 1.2 million, the traffic ratio reaches nearly 500,000 vehicles.

Road congestion is customarily been linked to factors such as poor parking amenities, improper parking of vehicles, despite traffic signs, and more importantly, being a result of intense traffic on roads, particularly in the urban regions.

The transport problem if not properly addressed in Mauritius is likely to result in the following problems: lowered level of productivity and efficiency, longer time wasted in travelling as well as an increased level of pollution, coupled with sound and carbon emissions from vehicles. Moreover, it has recently been reported that traffic congestion cost the Mauritian economy MUR 20 billion per year.

Why AI in transport for Mauritius?

Major challenges facing the transportation industry such as capacity problems, safety, reliability, environmental pollution, and wasted energy, provide ample opportunity for AI innovation in Mauritius.

The transport network is made up of multiple modes of transport operated by numerous entities who may have common or conflicting goals. The network is highly stochastic, with demand changing on a daily basis, and subject to sudden perturbations as unexpected events occur. Such networks have the ability to generate large volumes of data from vehicle telemetry, real-time tracking, ticketing systems, CCTV, sniffer beacons, in-vehicle information systems and Twitter feeds amongst others. Outside public transport, information sources include road traffic management systems and weather data collection systems.

The implementation of AI in the public transport domain will assist transport technology in predicting future demands on transportation and learning to provide better, more efficient solutions. These predictions could also quickly adapt to disturbances such as traffic incidents and public emergencies, increasing the safety of cities and infrastructure.
Times are changing when it comes to the world of transportation and powered by big data, artificial intelligence and the internet of things, the system is poised to become safer, more efficient and smarter.

International Developments

Autonomous vehicles

Small scale autonomous bus trials have been initiated all over the world in recent times most prominently in Finland, Singapore and China. The global non-uniformity in built-up structures, city infrastructures, road surfaces, weather patterns and traffic patterns make AI applications in autonomous trucks for on-time delivery of people and packages, highly environment specific. The aim of implementing autonomous vehicles is hypothetically to cut the number of road accidents.

Based on technology, AI in transportation market is categorized into deep learning, computer vision, and NLP. Among these, the deep learning category is estimated to account for the largest share, as this technology is being increasingly used in various AI related applications in the development of self-driving trucks. This category would also see a robust growth during the forecast period, and as far as transportation of goods is concerned, trucks might become more intelligent with the ability to drive on varying situations such as road terrains and unfavorable weather conditions.

Traffic management operations

AI solutions have been frequently applied in resolving control and optimization problems. It interesting to note that AI is already being used in applications like prediction and detection of traffic accidents and conditions, by converting traffic sensors into 'intelligent' agents using cameras.

For instance, traffic management systems are expected to work on a radar-based monitoring with the help of AI. This would enable the police to analyse the traffic pattern, volume, number of vehicles, and other factors, and collect data on a cloud. This information would then be used to manage the traffic, with automated traffic signals being one of the key tools.

One of the aims of AI being to reduce manual interface to minimal, smart traffic signals though AI will make use of machine learning technology to improve traffic monitoring and data analytics in the transportation sector. It will enhance detection accuracy and turn the collected data from cameras and sensors into valuable insights. The insights can then be used for event prediction to prevent road traffic injuries, eliminate peak-time traffic congestion, enhance operational efficiency or for future planning of traffic infrastructures.

In the same spirit, AI-powered real-time traffic updates through services such as Google Maps, have the ability to predict and analyse traffic conditions in local areas to enable better decision making.

Safety and Efficiency

- AI innovation in the domain of safety and efficiency has led to the creation of sophisticated devices that are able to monitor any indicators of tiredness, fatigue or illness suffered by a driver, and alert the command centre if anything unusual is detected. Such technology is usually fitted in front of bus drivers.

- Likewise, smart pedestrian signals are run by a system based on sensors connected to a ground optical system, and synchronised with the signal's light operation. It uses AI to perceive the pedestrian movement and automatically readjusts the remaining time based on the inputs for safe crossing for the largest possible number of pedestrians in a smooth manner with minimal impact on the movement of vehicles.

- AI is also being used in law enforcement capacities, in helping to identify and catch drivers who drink and/or text while driving. It is a challenge to human officers due to the speeds at which vehicles and passengers can come into and out of view.
  By using advanced analytical and data processing capabilities, AI could help to detect and identify when a driver is drinking or texting behind the wheel and alert any officers within the local area to intercept them.

Other developments

S.No	AI Function	Typical use-case
1	Nonlinear prediction (Prediction of the behavior of systems in which inputs and outputs are non-linear)	Traffic demand modeling, or in modeling the transportation infrastructure health as a function of traffic, construction and weathering.
2	Control Functions	Signal control of traffic at road intersections, ramp metering on freeways, dynamic route guidance, positive train control on railroads
3	Pattern recognition	Automatic incident detection, image processing for traffic data collection and for identifying cracks in pavements or bridge structures and transportation equipment diagnosis.
4	Clustering	Identifying specific classes of drivers based on driver behavior, for example.
5	Planning	AI-based decision support systems for transportation planning as discussed in the sections below.
6	Decision making	Deciding whether to build a new road, how much money should be allocated to maintenance and rehabilitation activities and which road segments or bridges to maintain, and whether to divert traffic to an alternative route in an incident situation.
7	Optimization	Designing an optimal transit network for a given community, developing an optimal work plan for maintaining and rehabilitating a pavement network, and developing an optimal timing plan for a group of traffic signals.

Case studies

Jakarta

With smart transport gathering speed in Asia, Jakarta has been collecting data from a new transport payment system, the Jakarta One card. The aim is to track the number of passengers in a particular area and their respective destinations, to subsequently feed public transport officials with information to plan new routes in the future.

Singapore

Across the strait, the Singapore government has also launched the Beeline app, which mines data collected from the transport payment system to suggest new routes for small private buses. It also crowdsources for possible new routes.

Singapore's buses are also equipped with sensors that predict bus arrival times and passenger counts, updating in real-time to an open data platform. App developers can input and develop their own algorithms to improve the reliability of the data.

The country is also using data to help predict transport fleet maintenance. Drones are helping to inspect track and tunnel conditions. Meanwhile, sensors on trains and buses to collect data on equipment wear-and-tear to help predict the next equipment failure using AI.

India

In India, the Delhi government is planning to invest around ₹1,000 crore in intelligent traffic management system, with an aim to overhaul the existing traffic system in its capital. India's transportation system is grappling with inadequate and inefficient public transport infrastructure, organised public transport in few cities and increasing rates of motorisation.

The new traffic management system will work on a radar-based monitoring with the help of AI. In certain situations, these intelligent services have been extended to crowd management and service delivery as well and the testing new technology has enabled the management vehicular and transportation traffic at one of the world's largest religious gatherings.

China

China plans to create an intelligent transport system by 2030. The country hopes to build smart roads that will not only be able to charge electric cars as they drive but also monitor temperature, traffic flow and weight load using AI. The prototype of the road is already in place on an expressway outside of Jinan, providing higher quality traffic updates as well as more accurate mapping.

Types of AI solutions to be deployed in Mauritius

AI driven traffic management operations would be highly beneficial for Mauritius as road congestion is an issue drawing the attention of the authorities. The following advantages would accrue:

- Better scheduling solutions in real time based on passenger demand
- More accurate information in the hands of the passengers, increasing public transport reliability and utilization
- Decreased congestion through better management of city traffic
- Increased efficiency and productivity through the automation of public transport

AI can also be incorporated to the Metro Express project to cater about safety, passenger amenities, better revenues, growth and efficiency. AI has to be harnessed to find digital innovations for better customer interface and better service delivery for the flagship project.

Challenges

Developments in the field of AI in Mauritius will cause authorities to rethink job descriptions and figure out when humans should be at the helm or when they should defer to smart machines for safety, cost savings and capabilities. There might be high resistance to the implementation of AI solutions in Mauritius.

Another major restraint to the growth and development of AI in transportation market is the high cost of AI system. Most of the artificial intelligence applications are complex in nature and so, very expensive, which restrict its growth, especially in emerging economies. The high cost of AI system is due to the following factors:

- The cost of LIDAR/RADAR sensor, cameras, GPS devices, hard drive, graphics card and other hardware and software devices is high and increases the overall cost of AI system.
- The need of advanced features such as blind spot detection, ADAS, ACC, and control wheel steering also adds up to the total cost of the AI system.

Moreover, worldwide there is no standardization of the sensing infrastructure and AI techniques used. Infrastructure costs, differing priorities among cities, and the high coordination costs among the parties involved have slowed adoption, as have public concerns over privacy related to sensing.

Artificial Intelligence in BPO sector

With the emergence of Artificial Intelligence (AI) Business Process Outsourcing companies must evolve to a new level.

Robotic Process Automation is a technology that will allow the BPO sector to be automated by configuring computer software, or a "robot" to emulate and integrate the actions of a human interacting within digital systems to execute a business process just like the employees do in the BPO industries. RPA robots utilize the user interface to capture data and manipulate applications just like humans do. They interpret, trigger responses and communicate with other systems in order to perform on a vast variety of repetitive tasks. Only substantially better: an RPA software robot never sleeps, makes zero mistakes and costs a lot less than an employee.

AI and its impacts on BPO sectors

As per research, impacts of implementing AI in the BPO sector are:

Employment

Firstly, there will be huge impact on employment, as many employees will be replaced by AI and Robotic Process Automation. According to a research carried out in India by US-based research firm HFS Research about 700, 000 low skilled workers in IT and BPO industry are likely to lose their jobs by 2022.

In Mauritius there are over 23,000+ employees in the IT and BPO Industry. With implementation of AI and automation in these sectors there may be a number of layoffs.

Cost of implementation

Secondly, to set up technologies like AI and RPA the cost is very high and BPO companies will need to invest massively for the implementation initially. Also, experts in the field will need to be recruited and equipment will need to be bought from overseas. Additionally, maintenance cost of such system is very high.

Furthermore, these technologies are currently in the developing stages even if now they invest a lot in the near future they will need to spend more money since these technologies are constantly evolving and the BPO will eventually need consistent upgrades.

Unsatisfied Customers

Artificial Intelligence is an area of opportunity that BPO companies will use to bridge the gap with their customers by improving customers engagement and service delivery. However, some higher valued customers may not prefer to receive assistance from Robotic Process Automation as they may not get the exact and required assistance they need as RPA is pre-programmed to provide certain kind of assistance which are sometimes limited and cannot go in more detail.

Salary Cost

Since the BPO companies will be automated, fewer employees will be required thus reducing the salary costs.

Reduced Workload

Employees in the BPO sector will no longer need to do repetitive tasks that eventually result in health issues such as anxiety, stress and depression.

Errorless Functioning

With AI and RPA there will be an errorless functioning in the BPO sector as all the tasks performed by these technologies are accurate.

Artificial Intelligence for Citizen Services and Government

Introduction

Since the earliest days of the Internet, most government agencies have eagerly explored how to use technology to better deliver services to citizens, businesses and other public-sector organizations. Early on, observers recognized that these efforts often varied widely in their implementation, and so researchers developed various frameworks to describe the different stages of growth and development of e-government. While each model is different, they all identify the same general progression from the informational, for example websites that make government facts available online, to the interactive, such as two-way communication between government officials and users, to the transactional, like applications that allow users to access government services completely online.

However, with the emergence of Artificial Intelligence (AI) e-government must evolve to a new level: the perceptive Stage. AI is a technology or system that can emulate human performance, for example, by learning, coming to conclusions or engaging in dialogues with people. Machine learning is a category of AI that aims to extract knowledge or patterns from a series of observations.

The defining feature of the perceptive stage will be that the work involved in interacting with government will be significantly reduced and automated for all parties involved. This will come about principally from the integration of artificial intelligence (AI) - computer systems that can learn, reason and decide at levels similar to that of a human - into government services to make it more insightful and intelligent.

AI and its impact on Government

While the potential future use cases of AI in government remain bounded by government resources and the limits of both human creativity and trust in government, the most obvious and immediately beneficial opportunities are those where AI can reduce administrative burdens, help resolve resource allocation problems, and take on significantly complex tasks. Many AI case studies in citizen services today fall into five categories: answering questions, filling out and searching documents, routing requests, translation, and drafting documents. These applications could make government work more efficient while freeing up time for employees to build better relationships with citizens. With citizen satisfaction with digital government offerings leaving much to be desired, AI may be one way to bridge the gap while improving citizen engagement and service delivery.

Though AI is still in the developing stages, there are steps government agencies can take today to lay the foundation for the technology of tomorrow. In particular, investments in modernizing their data architecture and building application programming interfaces so that they will be able to use AI on the data they already collect. In addition, there must be a close collaboration with other external as because most government agencies are not going to have the in-house expertise to build AI systems. Artificial intelligence is an area of opportunity that government agencies can actively anticipate and plan for when upgrading their legacy systems.

There are three major ways that AI will impact government agencies:

1. First, it will enable government workers to be more productive since the technology can be used to automate many tasks. While computers have already done this to an extent, AI allows computers to take on significantly more complex tasks, such as recommending medical treatments. AI can be used to search for patterns, discover new insights, extract meaning from raw data, make predictions, and interact with people, machines and the physical environment.

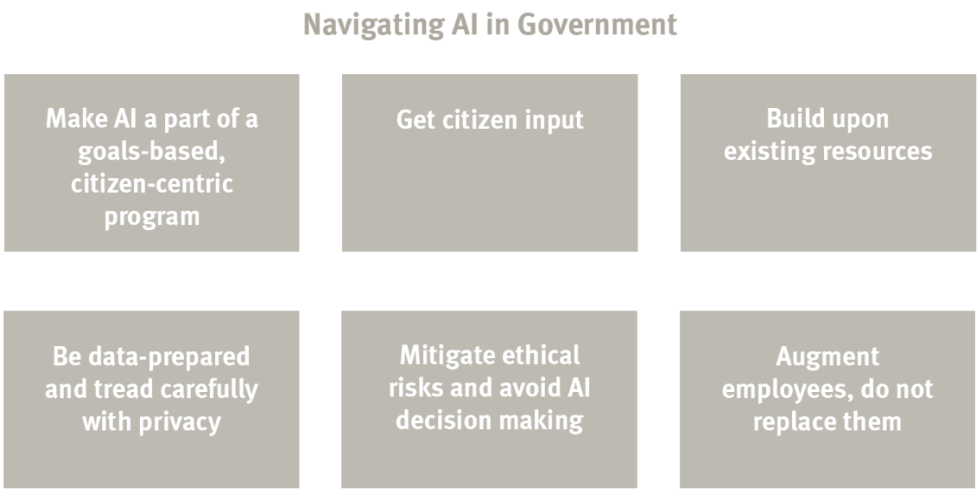
2. Second, AI will create a faster, more responsive government. AI enables the creation of autonomous, intelligent agents, for example online catboats that answer citizens' questions, real-time fraud detection systems that constantly monitor government expenditures and virtual legislative assistants that quickly synthesize feedback from citizens to lawmakers.

3. Third, AI will allow people to interact more naturally with digital government services. Until recently, most interactions with computers required people to adapt to the needs of computers. Users push buttons on an ATM or move a mouse on a PC, not because these are the most intuitive ways to communicate as a human, but because these are the easiest ways to communicate with a computer. But improvements in natural language processing and speech recognition have given rise to virtual assistants like Apple's Siri, Amazon's Alexa and Microsoft's Cortana, which allow users to speak to a computer much like they would a human and increasingly in many different languages.

For many systemic reasons, government has much room from improvement when it comes to technological advancement. In addition, there is hype around many modern tools, while most government offices are still trying to reach more basic modern operating standards.

Nevertheless, there is benefit in preparing for the future, and making technology investments to keep pace with trends in how citizens prefer to engage with service providers. Governments can start thinking about implementing AI by learning from previous country government transformation efforts and AI implementations in the private sector.

Some strategies can help governments start off on the right foot with AI: make AI a part of a goals-based, citizen-centric program; get citizen input; build upon existing resources; be data-prepared and tread carefully with privacy; mitigate ethical risks and avoid AI decision making.



Types of Government Problems Appropriate for AI Applications

- **Resource Allocation**-Administrative support is needed to speed up task completion and inquiry response times are long due to insufficient support.
- **Large Datasets**-Dataset is too large for employees to work with efficiently Internal and external datasets can be combined to enhance outputs and insights. Data is highly structured with years of history
- **Procedural**-Task is repetitive in nature and inputs/outputs have binary answer
- **Diverse Data**- Data includes visual/spatial and auditory/linguistic information Qualitative and quantitative data needs to be summarized regularly

Recommendations

For Artificial Intelligence and other emerging technologies to have the required impact, both economically and socially, there is the overarching need for a coordinating body with substantial funds to oversee implementation of specific projects, which are detailed in what follows.

Mauritius Artificial Intelligence Council

1. The introduction of the Mauritius Artificial Intelligence Council will scale opportunities in this field. The Government will be setting up a task force to develop a road map for Mauritius which will be responsible for project implementation and monitoring as well as quantifying the socio-economic impacts of the promotion of AI.

2. The Council will be, inter-alia, responsible to coordinate with all stakeholders and define specific projects with clear milestones, responsibilities and implementation timelines to foster the AI venture in Mauritius.

3. A conducive environment should be created and ensured by Government, but projects will need to be driven by the private sector to ensure that federating projects have adequate support, implementation capacity and clear and impactful deliverables.

4. The Mauritius Artificial Intelligence Council as announced in the last budget should be responsible to coordinate, monitor and disburse funds for the selected projects, which would be determined in the report of the working group.

5. The EDB will work with other stakeholders in defining the best structure for the Council.

6. The MAIC should further extend its role in coordinating, implementing and monitoring innovative projects and technology adoption such as blockchain and IOT amongst others.

Funding and incentives

7. The risk for start-ups in AI and Fintech remains significant. The Government should be able to share the risks through an appropriate mechanism which may take the following forms:

- Matching grants, similar to the schemes that exist at the level of the MRC, although care should be taken that the schemes cater for adoption of existing solutions by private companies as well as development of new solutions.
- Tax credits
- Fiscal incentives
- Equity financing
- Training grants (local and abroad)
- Plough-back of profits into investments in AI

8. It was emphasized that the mechanism should take into consideration that the concern will be more on the adoption on AI than development.

Skills development

9. Globally, Governments are all well aware of the limited supply of AI talent and are trying to get ahead of the new challenges caused by AI. To conduct R&D in AI and deploy AI solutions in the public and private sectors, countries need a supply of skilled AI talent. Mauritius is no exception and its success in the AI space will be directly related on its ability to train and attract the talent needed for basic AI research, the design of applications that use AI algorithms and the adoption of AI and AI-related technologies by local businesses.

10. In the short-term, foreign expertise will need to be brought to Mauritius while concurrently training a pool of computer scientists and mathematicians, over the medium term, or HSC holders in the longer term to ensure we have sufficient capacity to deploy AI solutions in sectors targeted. Africa can be a target market as well.

11. The right framework to bring in talents from abroad needs revamping. The Mauritian Diaspora Scheme and the Innovator's Occupation Permit exist as possible solutions but remain quite prohibitive and may need to be reviewed by making the conditions less stringent.

12. In the medium term, an AI campus of around 100 students with a tailor-made programme, worked out with the support of the local universities and international experts, could be envisaged. The cost is expected to be around MUR 10 MN, and the course may be designed to be completed in around 6 months. The trained professionals would help in deploying AI solutions across companies and authorities.

13. Existing elective modules at University level should be reviewed and programming and coding should be made mandatory for all subjects.

14. Scholarships for advanced training in AI should be made available to locals and foreign students in Mauritius.

15. For longer term solutions, there should be concerted efforts and ramping up of current initiatives to promote science and technology and mathematical literacy, and to increase digital science and AI training from the high-school level to the university level. It is important that the pipeline of graduate students in AI-related fields should be built through the democratization of science and the promotion of careers in the mathematical sciences from the primary school level.

16. Investments in STEM education, national retraining programs, and lifelong learning should be considered to ensure that workers have the skills to compete in the digital economy. Training needs to be done in collaboration with universities and associated educational institutions.

17. A "talent watch" should be established for the benefit of all ecosystem stakeholders, including educational institutions, which can use it to review their programs accordingly. Basically, the "talent watch" would be responsible to determine the industry's needs in terms of AI and AI-related profiles and skills, with a view to matching training to employment. It is thus important to ensure a link and a transparent dialogue between the "talent watch" and educational institutions.

18. The approval process at the level of MQA should be reviewed, to allow universities to rapidly amend their training offerings to meet the growing need for a skilled AI labour force. Interuniversity

collaboration should be promoted to ensure baseline coordination between university programs and offer substantive training programs that make it possible for students to access the departments and expertise at other universities.

19. While training for professionals in the sector is necessary, the reskilling of workers capable of being displaced needs to be addressed. A scheme should be put in place to enable such workers to acquire skills to improve their occupational mobility.

Projects

20. It is proposed that the MAIC also convers Blockchain backed projects. To that end, it is advised that that national projects making use of Blockchain technology be earmarked and implemented with an aim to test efficiency and build capacity in Mauritius. Projects may include, inter-alia:

- Tax payment;
- Land registration;
- Managing health insurances.

21. AI can highly improve the energy sector in Mauritius namely by:

- Using IoT and neural algorithms to increase energy efficiency;
- Use AI in smart grid systems and improve on efficiency as well as enabling the increase of renewable penetration in the national grid;
- Use of AI to perform dynamic energy storage and distribution to reduce storage cost whilst enabling additional renewable energy penetration in the national grid

22. The manufacturing sector is in a constant quest for productivity improvement. AI can be a key enabler in booster efficiency and competitiveness in this sector. Proposals include:

- Providing strong fiscal incentives for the acquisition and implementation of services and technologies aiming at enabling data acquisition, big data management and data driven operation and maintenance;
- National Productivity and competitiveness council, SME Mauritius Ltd and other stakeholders to support mentorship and companionship in promoting the implementation of AI and related technologies in enterprises;
- HRDC, MRC, EDB, and the MAIC to support training and R&D initiatives to support integration of AI to enable gain in productivity and reduction in operation and maintenance cost.

23. AI can give a leap frog move to the healthcare and biotech industry. Proposals and recommendation include, inter-alia,

- Supporting research institutions in building databases of organisms and genomic data of patients;
- Supporting the structuring of projects aiming at developing precision medicines;
- Support e-health initiatives.

24. The Agro-Industry is in a quest for gain in productivity to compete with international prices. Proposed projects to be unrolled with the support of Government may include:

- Using neural and history-based networks to perform precision agriculture by correlating productivity with market demand and value;

- Using AI supported drone vision for early detection of diseases and supporting harvest;
- Use of IoT and AI to determine pest and other chemicals requirements and move into precision use of chemicals;
- Use of AI to associate sound specificities with prevalence of pests and predators and advise to maintain sustainable population of the latter.

25. The Ocean Economy as envisaged to become a key pillar of the Mauritian economy will require massive data and an ability to translate the data into commercial outputs. AI can support several initiatives namely in unrolling the smart port concept which relates to digitalizing all port clearances and ensure logistics optimization. Ai can further support the development of the marine biotechnology sector by modeling the impact of isolated compounds on specific genomic characteristics.

26. Transport

- Combining AI with safe city project to model frequency of passengers, optimize public transport and security;
- Use of AI to monitor speed of vehicles through image recognition;
- Use of AI to monitor effect of infrastructures on traffic and advise and model the impact of new proposed infrastructure on traffic.

Regulatory framework, ethics and data protection

27. A vital catalyst to artificial intelligence innovation will be a suitably robust legal and regulatory framework. At present we are looking to old laws to deal with these new technologies. Good regulatory policies build public trust. For technologies to receive widespread acceptance, the public must be convinced that their safety, privacy and data are safeguarded.

28. The current regulatory framework furthermore may act as major constraint to instilling R&D and innovation in Mauritius, especially in terms of defining Intellectual Property rights which would also need to be well defined. The IP Bill should be expedited.

29. Following development of solutions in AI, even following Government support, the IP should remain in its totality with the private developer.

30. The current regulations also need to be properly addressed to allow AI to develop, especially in Fintech and other such areas where outdated regulations in terms of mobile payment, crowdfunding and crowdlending amongst others are hindering the expansion of the sector.

31. Accountability will be a key element to discuss for when things go wrong. The question of liability in artificial intelligence is very complex compared to most other environments. Given the multiple participants involved in any artificial intelligence value chain, an efficient way of solving the liability problem will be for the various market players to define the parameters of their own liabilities.

32. The AI ecosystem should be ethical, and therefore, a permanent committee on ethics should be set up to maintain the dialogue and formulate proposals to maintain a healthy relationship between AI and humans.

33. Poor data governance can result in an unintentional release of secure or private/confidential information where customers' personal identifiable information that feeds an algorithm may get into the hands of hackers and can cause legal challenges for the organization. Necessary amendments to Data Protection legislations need to be addressed by a special working group.

34. Furthermore, a policy direction about open data and access to such platforms, with the adequate infrastructure should be considered, with the possibility of Government setting up a data centre.

35. Another vital component of the legal framework will be ensuring that humans have the ability to override artificial intelligence decisions and maintain control over the technology.

Networks and clusters

36. A Technology Park or cluster is preconized, which will bring together private sector, start-ups and training schools to catalyse the collaborative approach idea with models such as Silicon Valley, keeping in mind the specificities of Mauritius.

37. The collaborative approach will need the support of international experts and academia to engage in a continuous discussion on the possibilities and opportunities of AI. Universities and other research institutions should create bridges in this respect.

38. The MAIC should forge ties through MOUs and exchanges with international networks on AI to catalyse the adoption of the technology.