Artificial Intelligence & The Caribbean: A Discussion Paper on (Potential) Applications & Ethical Considerations

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Abstract

Artificial intelligence (AI) is poised to yield significant productivity gains, with manifestations in improved national competitiveness, transformed delivery of public services and economic and developmental benefits. For the Caribbean, harnessing this potential could be the solution to several ongoing developmental challenges. However, such benefits can become quickly eroded if the associated ethical risks of these technologies are not properly addressed. Consequently, any discussion aimed at seizing AI's benefits must not focus solely on potential applications, but must also include some level of dialogue related to ethical concerns. Against this background, this paper not only assesses the state of play of AI in the Caribbean and its potential utility, but also addresses three related ethical concerns, notably unemployment fears due to increased automation, biased outcomes in AI and implications for privacy and data protection.

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1 Introduction

Contextual Background

Considered the next digital frontier, Artificial Intelligence (AI) has received increasing global attention, but remains a term without a universally accepted definition. According to the Organisation for Economic Cooperation and Development (2016), AI includes machines and systems with the ability to acquire and apply knowledge and to execute intelligent behaviour, such as learning, reasoning, sensing and decision-making. AI systems can be purely software-based operating within the virtual world (speech and face recognition systems, search engines, voice assistants, etc.) or embedded within hardware devices (autonomous cars, advanced robots, drones, etc.), but their defining characteristic resides in their cognitive abilities (European Commission, 2018). Thus, rather than conceptualizing AI in a singular sense, it is necessary to recognize the term's expansive portfolio within current technological developments and processes (European Union Agency for Fundamental Rights, 2019).

AI is poised to yield significant productivity gains, with manifestations in improved national competitiveness, transformed delivery of public services and economic and developmental benefits (United Nations Economic and Social Commission for Asia and the Pacific, 2017). For the Caribbean, harnessing this potential could be the solution to several ongoing developmental challenges. However, such benefits can be easily eroded by the far reaching consequences of the associated ethical and legal implications of these technologies. To conceptualize such, one only needs to consider the implications of increased automation on job security; or think about the potential privacy invasion stemming from unfettered access to data by these systems; or consider their potential to exacerbate existing inequalities by producing biased outcomes. So although it is easy to become mesmerized by the wonder and hype of advances in AI, great consideration must still be given to the important societal concerns raised by these technologies.

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Research Overview

Against this background, this paper aims to bring increased visibility to the field of AI in the Caribbean, primarily through discussion focused on (potential) applications and ethical considerations. With that in mind, the paper is divided into two main sections. Section 1 assesses the current state of play of AI in the Caribbean, while commenting on the potential utility of such technologies within developmental areas in the region, notably – in healthcare, agriculture and education. Section 2 develops a discussion which addresses three main ethical concerns, namely the implications of AI on job security; the potential for AI to produce biased outcomes; and the implications of AI's data requirements on data protection and privacy.

The findings and analyses of this paper are limited primarily to the Caribbean Community (CARICOM)[1]. This paper was compiled exclusively from desk research and official databases such as the World Bank, the United Nations, the World Economic Forum and the Organisation for Economic Co-operation and Development, among others were used to source statistical data. Reports from local news outlets were also used in order to gather insight on the relevant activities of individual CARICOM Member States. Limitations included data constraints and the lack of previous studies on AI particularly related to the Caribbean.

It is envisioned that this paper's discussion will not only encourage thought provoking dialogue on AI in the Caribbean, but that it will also promote future research capable of better positioning the Caribbean to take advantage of the new opportunities presented by AI.

1 CARICOM is a common market comprised of fifteen Caribbean states including: Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago. Its goal is to promote economic integration and cooperation amongst its members. It remains one of the primary institutions under which regional efforts for the Caribbean are mobilized and enforced

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2. Section 1: The state of play of AI in the Caribbean

The Caribbean's engagement with AI can be analysed from three perspectives, notably:

(i) AI-related research and development (R&D)
(ii) Application of AI technologies
(iii) AI-related policy

AI-related R&D

Globally, advanced economies are investing billions of dollars into AI-related R&D (see Figure 1). In fact, when compared to the size of some Caribbean economies, the magnitude of these investments[2] far outweigh total GDP. Consider the GDP of CARICOM Member States in 2018, which ranged from USD 23 billion to USD 62 million[3] (United Nations, 2020). Evidently, some countries are investing more into AI R&D than the total GDP of CARICOM's largest economy. Rather than a simple comparison, this revelation highlights the significant financial constraints that Caribbean states are likely to face even with the best intentions to promote AI-related R&D, especially without private sector investment or foreign direct investment (FDI).

2 *Note that figure 1 only captures government investment, overall investments for these countries substantially increases when private investments are considered.*

3 *Trinidad and Tobago had the highest GDP (USD 23 billion) while Montserrat had the lowest GDP (USD 62 million), among CARICOM member states during 2018.*

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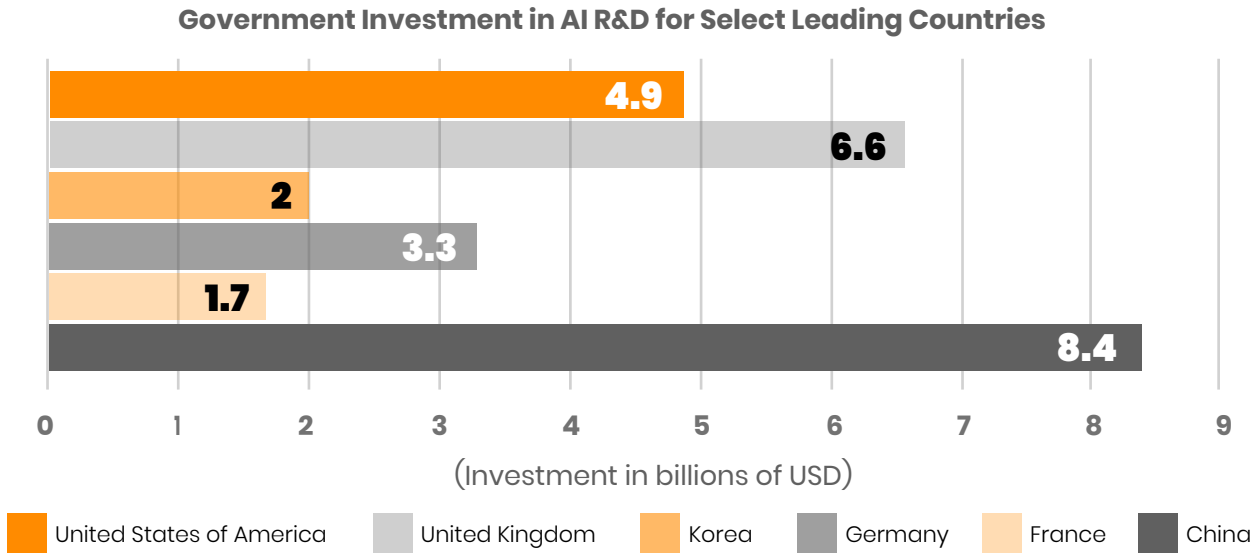

Figure 1. Government Investment in AI R&D for Select Countries - Source: Author's compilation from Organisation for Economic Co-operation and Development (2019); Loucks et al. (2019); Acharya and Arnold (2019); Congressional Research Services (2019); Cornillie (2019). Note for China, there are no official government investment figures but estimates range between USD 2 to 8.4 billion. Note for the USA, this figure represents the Federal Government's proposed investment in unclassified AI R&D.

Data, where available, indicates that Caribbean economies spend very little on R&D (see Table 1), and the extent to which such spending is attributed to AI or related digital fields is unknown. Regarding FDI, more current information is available, which shows that in 2019 FDI inflows (excluding offshore financial centres) to the Caribbean declined by 32% to USD 3 billion (United Nations Conference on Trade and Development, 2019). Traditionally, investments in commodities have underpinned the region's FDI inflows but a continuous shift towards infrastructure and consumer goods particularly related to information and communication technology (ICT) has emerged, and is expected to experience steady growth (United Nations Conference on Trade and Development, 2019). Although there is no clear indication about the overall amount of FDI explicitly dedicated to AI-related R&D in the Caribbean, investments in related areas like ICT and digital transformation provide some evidence of relevant activity (see Table 2).

COUNTRY	R&D EXPENDITURE (% OF GDP)	YEAR
Trinidad & Tobago	0.09	2016
Jamaica	0.06	2002
St. Lucia	0.33	1999
St. Vincent & the Grenadines	0.30	2002

Table 1. R&D Expenditure of Caribbean Governments - Source: Author's compilation using data from World Bank (2020a).

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COUNTRY	PROJECT	AMOUNT (USD)	FUNDING SOURCE / ASSISTANCE
Barbados	Public Sector Modernization Programme – This aims to increase digital channels for public services and to strengthen the development of a digital economy.	40 million	Inter-American Development Bank Loan (approved in 2019)
Grenada	Digital Government for Resilience – This involves a digital transformation in the delivery of public services.	15 million	IDA Credit - World Bank (approved in 2019)
	ICT Centre For Excellence and Innovation – Amongst the objectives of the centre include the establishment of a virtual reality lab for the promotion of technologies in the area of AI.	N/A	Government of India (Government of Grenada signed an agreement in 2008 with the Government of India to finance this centre)
St. Vincent & the Grenadines	ICT Technical Cooperation Project - This project has three main objectives including: to develop a National ICT Centre; enhance e-government capabilities; and transfer Taiwan's comparative advantages in the ICT sector.	N/A	Taiwan International Cooperation and Development Fund (Project duration: 2011/1/1 – 2015/11/7)
St. Kitts & Nevis	National ICT Centre Re-opens – The National ICT Centre was first opened in 2007 as part of an agreement between the Republic of China (Taiwan) and the Government of St Kitts and Nevis on cooperation in information and communication technology. It has since been enhanced and re-opened in 2018.	N/A	Republic of China (Taiwan) (Established in 2007)
Jamaica	ICT Centre – The Government of India established an IT Centre under the ICT Capacity Development Project in Jamaica.	N/A	Government of India (Established in 2009)

Table 2. ICT-related Investments in the Caribbean - Source: Author's compilation from Inter-American Development Bank (2019); World Bank (2019); Government of Grenada (2011); Taiwan International Cooperation and Development Fund (2020); The St. Kitts Nevis Observer (2018); Jamaica Information Service (2008) – Note that this is not an exhaustive list.

More directly there are three cases of FDI specifically linked to the promotion of AI-related R&D across various Caribbean islands (see Figure 2). The examples of GIBC Digital and OJO Labs (Figure 2), reflect a familiar Caribbean experience where promised outcomes from FDI are not always fulfilled, much to the detriment of the host country. Furthermore, it highlights the sustainability challenge whereby projects financed through various funding programmes are often not developed in such a way to support their continued existence. For this to occur especially in AI-related R&D, the Oxford Government AI Readiness Index suggests that countries must be able to connect their academic resources with private and public

capital (Oxford Insights and International Development Research Centre, 2019). Consistent with this logic, is the bmobile-University of the West Indies (UWI)[4] Innovation Lab powered by Huawei (Figure 2). This tripartite agreement which leverages existing academic resources with private and public capital is expected to be pivotal in the commercialization of academic research in the field of emerging technologies.

GIBC DIGITAL	OJO LABS	HUAWEI
• GIBC Digital is an American firm specialized in automation, AI, machine learning, data visualization and business intelligence. • In 2018, GIBC Digital sought to establish a "state-of-the-art" Data and AI Centre in Grand Bahamas, the Bahamas. • Expected completion for the centre was forecasted for 3 years, with an initial investment of USD 2.5 million and a subsequent investment of USD 1 million. • During 2019, GIBC Digital's physical office in Grand Bahama was closed, with little known about the project's future continuation.	• OJO Labs is an American technology-driven firm founded on the desire to improve decision-making by bringing technologies like AI and people together. • During 2017, OJO Labs announced its intention to open an AI Training and Call Centre in Vieux Forte, St. Lucia • More than three years later, it appears that little emphasis has been attributed to the development of the centre's AI component.	• Huawei Technologies Co. Ltd. Is a Chinese multinational technology company, providing telecommunications equipment and consumer electronics. • In 2019, Huawei donated USD 13 million in equipment as part of a tripartite agreement between the University of the West Indies (UWI) St. Augustine Campus, bmobile (Trinidadian telecommunications service provider), and itself, for a "state-of-the-art" Innovation Lab at the University of the West Indies, St. Augustine Campus in Trinidad and Tobago. • This lab aims to create an environment where emerging technologies even in the field of AI can be locally researched, developed and tested.

Figure 2. FDI Related to AI R&D - Source: Author's compilation from The Bahamas Investor (2018); Robards (2019a); Aurelien (2018); UWI (2019a).

It is worth considering the capacity of the region's existing academic framework for supporting the development of AI-related R&D. Education remains a priority for Caribbean economies (see Table 3), but concern about the system's ability to meet the emerging needs of the fourth industrial revolution exposes a need for reform[5] (Caribbean Examination Council, 2015). At the tertiary level where research is encouraged there are various institutions across the Caribbean, however, this analysis focuses on the region's main tertiary institution - The University of the

4 The UWI is the region's leading tertiary institution serving the higher education and research needs of primarily the Commonwealth Caribbean.

5 Although subjects like Information Technology and Computer Science provide basic exposure for students at secondary school, there is a need for greater integration of technologies into the region's education system in a way that develops life-long digital skills. Furthermore, Trinidad and Tobago's Minister of Education, Anthony Garcia, has announced his intention to introduce AI in all schools across the island (Hassanali, 2019).

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West Indies (UWI)[6]. Although criticized for producing insufficient research on big-idea projects and topical issues (Matthews, 2018), the UWI has been involved in some AI-related R&D activities. Apart from the aforementioned Innovation Lab, the UWI St. Augustine Campus hosted two AI solutions workshops in conjunction with Google during 2019 (UWI, 2019b); as well as a distinguished open lecture in 2018 by Nell Watson[7] entitled: "AI and Educating for Tomorrow" (UWI, 2018). Furthermore, the UWI Mona Campus' Faculty of Science and Technology has developed various research groups that have produced different AI-related research projects and publications (see Annex 1). However, it is worth noting that the UWI's overall AI-related publications are few when compared to other research areas and they tend to focus more on the functional design features of AI technologies, rather than softer aspects such as ethical and legal implications (see Annex 1). Nevertheless, across campuses at both under-and postgraduate levels not only are there courses explicitly addressing the fundamentals of AI, but there are also other courses which address related areas like ethics, data mining, algorithms, programming, etc. (see Annex 1) – all important areas within AI ecosystems. Thus, while AI research in the region appears presently limited, it is evident that there is an existing framework especially in faculties like Science and Technology where potential academic resources can be leveraged to support and encourage AI-related R&D. Furthermore, recognizing that this analysis only considers the UWI, it would be useful to consider the R&D work of other technology-focused tertiary institutions across the Caribbean.

Overall, findings under this subheading are indicative of minimal AI-related R&D activity in the Caribbean. However, as increasing attention is paid to advances in this area and more partnerships are formed, greater momentum and financing for AI-related R&D should occur in the Caribbean.

COUNTRY	EDUCATION EXPENDITURE (% OF GDP)	YEAR
Antigua & Barbuda	2.5	2009
The Bahamas	2.2	2000
Barbados	4.7	2017
Belize	7.4	2017
Dominica	3.4	2015
Grenada	3.2	2017
Guyana	6.3	2017
Haiti	2.4	2016
Jamaica	5.4	2018
St. Kitts & Nevis	2.6	2015
St. Lucia	3.8	2018
St. Vincent & the Grenadines	5.8	2017
Trinidad & Tobago	3.1	2003

Table 3. Government Expenditure of Education - Source: Author's compilation using data from World Bank (2020b).

6 The UWI is the region's leading tertiary institution serving the higher education and research needs of primarily the Commonwealth Caribbean with its five campuses which include: open campuses (located across various islands), the Cave Hill Campus (in Barbados), the Mona Campus (in Jamaica) and the St. Augustine Campus (in Trinidad and Tobago).

7 Nell Watson is a keynote speaker specialized in areas of technology and entrepreneurship.

Application of AI Technologies

AI is poised to yield significant productivity gains, with manifestations in economic and developmental benefits, improved national competitiveness and transformed delivery of public services. According to PricewaterhouseCoopers (2017), the application of AI technologies could contribute USD 15.7 trillion to the global economy by 2030, with an expected gain of USD 0.5 trillion for Latin America. Similarly, the Inter-American Development Bank (2018) predicts that AI applications could boost regional GDP for Latin America and the Caribbean in the mid-term to 4%. However, the amount of this attributed to the Caribbean, if at all, is unknown - which is not surprising when considering that studies focused on Latin America and the Caribbean as a region are often more reflective of Latin American countries. Studies dedicated to the application of AI technologies in the Caribbean appear minimal but a recent contribution by researchers of the Inter-American Development Bank sought to informally contextualize the use of AI technologies as solutions to the region's ongoing developmental challenges (Smets and Deyal, 2018).

At present, there is limited data on the use of AI in the Caribbean and absent such information conclusive findings are difficult to obtain. Figure 3 however, provides insight into some of the current applications of AI technologies across the Caribbean which have been publicly reported. From analysing these examples, partnerships with specialized foreign firms emerge as the general approach towards the application of AI technologies within these different sectors across the Caribbean. Although Figure 3 features examples at the national level, the Organisation of Eastern Caribbean States[8] (OECS) Commission recently signed an agreement with Facebook Caribbean to utilize Facebook's Disaster Maps on a regional scale to improve emergency response ahead of the 2019 hurricane season (OECS, 2019). While it is not clear whether Facebook's Disaster Maps is an AI powered tool, there certainly is scope for it to become one if consistent with the observed trend in Facebook's other Data for Good projects which are increasingly relying on AI technology. Evidently then, there exists AI application in the Caribbean at the national and potentially regional levels, but without further data it is difficult to ascertain the level of engagement that the region's private sector has had with AI technologies.

8 The OECS is a regional grouping formed mainly among the CARICOM's "least developed" countries. The protocol members which enjoy full membership include: Antigua and Barbuda, Dominica, Grenada, Montserrat, St Kitts and Nevis, St Lucia and St Vincent and the Grenadines.

Click2Clear (The Bahamas)

Click2Clear is a new customs management portal used in the Bahamas which according to public reports has incorporated elements of AI technology to detect inconsistencies in import trends and prices in order to plug revenue leaks and expose potential cases of fraud and tax evasion.

BICCo & RoadBotics (The Bahamas)

The Bahamas Industries and Construction Company Limited (BICCo) recently partnered with RoadBotics, an American firm specialized in AI-based road assessments, in order to utilize AI technology to conduct road assessments across the Bahamas.

The Hunt for the Crystal Maiden (Belize)

It was reported that the Belize Tourism Board (BTB), in conjunction with ICF Olson (a global marketing agency), developed an interactive game, "The Hunt for the Crystal Maiden", which utilized AI technology to create an immersive experience and elevate Belize's traditional tourism campaign, by drawing awareness to the island's underrated tourist attractions.

SIMM & Georgetown Public Hospital (Guyana)

The Society for Imaging Informatics in Medicine (SIIM) recently announced an AI collaboration with the Georgetown Public Hospital in Guyana, granting the hospital access to AI innovations in this field.

Figure 3. Reported Cases of AI Application in the Caribbean – Source: Author's compilation from local newspaper reports including Robards (2019b); The Tribune (2019); Thangavelu (2019); and ICF Olson (2019). Note – this is not an exhaustive list of cases of AI application in the Caribbean, rather it is a compilation of publicly reported cases of such.

Although the aforementioned examples capture the use of AI technologies in different areas like the medical field, customs management, construction, tourism, and disaster management, there is also significant utility for the application of AI technologies in other fields across the Caribbean, personal deductions of such are highlighted in Boxes 1,2 and 3.

HEALTH & WELLNESS

Brief Situational Overview

The Caribbean has the highest mortality rate for non-communicable diseases (NCDs), with 7 out of 10 deaths being NCD related. Added to this, the region suffers from a critical nurse shortage. These two factors, coupled with other resource constraints continue to hinder effective healthcare across the region.

Potential AI Utility / Solutions

Against the identified challenges of the region, relevant applications of AI in areas of diagnostics, lifestyle management and delivery of healthcare services are briefly highlighted below.

Through data mining, AI systems can better predict, identify and monitor NCDs, with 99.5% accuracy. Recently, the start-up company Fedo, developed a risk stratification AI system to predict patients' susceptibility to 7 different types of NCDs; while another start-up VITL, leveraged an AI engine to diagnose patients' nutritional needs and deficiencies, using a broad range of lifestyle and diet data points. Access to such technologies could play a pivotal role in the transformation of the region's healthcare system from treatment-based towards preventative-based healthcare. Not only does this transformation substantially reduce treatment costs, but it also encourages the development of a healthy population and workforce, which translates to productivity gains.

The development of AI virtual assistants to aid in the provision of healthcare services and clinical workflows are being streamlined in a manner that saves time and resources. Consider Dragon Medical Virtual Assistant which utilizes AI to deliver sophisticated conversational dialogues and healthcare skills that automate high value clinical tasks from chart search to computerized physician order entry. Leveraging the potential of such technologies could alleviate delays stemming from labour shortages, and significantly improve the region's quality of service.

Ethical Considerations

As with all AI applications, there is the largescale question of the impact that automation will have on job security. Additionally, access to patient data which is needed to train AI systems is likely to raise privacy concerns, especially given the sensitive nature of healthcare information. Even more concerning will be cases of unintended consequences (serious harm, death, misdiagnosis, etc.) which will unveil legal issues like malpractice and product liability. Cultural acceptance of such technologies in sectors traditionally dominated by 'human-interaction' must also be considered.

Box 1. The Potential Utility of AI in the Caribbean's Health & Wellness Sector – Source: Author's compilation using information from Healthy Caribbean Coalition (2017); Smets and Deyal, (2018); Mindfields (2018); Nuance (2019); OECD (2019); and Rigby (2019).

AGRICULTURE

Brief Situational Overview

Agriculture is a strategic sector for the Caribbean, not only in terms of food security but also as a key economic driver, providing a valuable source of foreign exchange and employment. However, in recent years despite geophysical advantages (conducive climate and fertile lands), the sector has fallen in crisis due largely to significant contractions in traditional exports, resulting from an erosion of trade preferences. Subsequently, regional agricultural production has declined, resulting not only in significant foreign exchange losses and a rise in unemployment, but also an increasing food import bill for the region, which is expected to reach USD 8-10 billion by 2020. With over 80% of food being imported into the region, CARICOM countries are now classed as net food importing developing countries, a status which increases their vulnerability and threatens food security.

Potential AI Utility / Solutions

- Crop and soil monitoring have been significantly enhanced by AI applications like Plantix, which correlate software algorithms with particular foliage patterns to identify nutrient deficiencies in soil, plant diseases and plant pests with 98% accuracy. aWhere uses AI technology in conjunction with satellites to predict weather conditions and analyse crop sustainability. Utilizing such technologies can directly increase the region's agricultural yields by reducing weather and pest-related losses. Such yield increases can subsequently reduce the region's food import bill.

- Agricultural robots are being developed to handle tasks such as harvesting and weeding. See and Spray is an AI-powered weed control robot which utilizes computer vision to monitor and precisely spray weeds on cotton plants, while reducing herbicide expenditures by 90%. Furthermore, Harvest CROO Robotics developed a robot capable of harvesting 8 acres of strawberries in a day, a task which would require on average 30 workers. The application of such technologies can yield significant cost-saving and productivity gains, capable of improving the region's competitiveness in this sector, which is particularly beneficial for increasing the region's agricultural exports.

Ethical Considerations

Various ethical considerations remain at play, some of which include: concerns of unemployment due to the automation of human tasks, a widening digital divide created by expensive costs which may limit access to these technologies by some farmers and data protection concerns. Beyond ethical implications, the physical infrastructure will also need to be reconfigured in order to render farmland amenable to the data collection that makes AI possible. Additionally, farmers will need to be able to interpret these results which may require a level of re-training in this sector.

Box 2. The Potential Utility of AI in the Caribbean's Agricultural Sector – Source: Author's compilation using information from International Labour Organization (2006); Food and Agriculture Organization of the United Nations (2015); Smets and Deyal, (2018); Sennaar (2019); Mateescu and Elish (2019) and Ryan (2019).

EDUCATION

Brief Situational Overview

Outlined within the CARICOM Human Resource Development 2030 Strategy is a strategic priority focused on reforming the education system, particularly the basic education, lifelong learning and tertiary education sectors. Under this priority are broad imperatives which include improving educational access, equity, quality and relevance. Among the identified needs are the design of multiple and flexible curricular pathways, adequate student support for disabled and special needs learners, greater alignment of skills development with needs of the digital economy and increased use of technologies, among others.

Potential AI Utility / Solutions

- AI technologies can be used to 'hyper' personalize learning through the development of personalized curriculums. By mapping a student's strengths and weaknesses against their learning plan and trajectory, different algorithms embedded within these systems are able to develop a road map of how a student learns. This not only allows students to better navigate through different content materials but also allows teachers to be better positioned to meet the individual needs of their students. Certainly, in the context of designing multiple and flexible curricular pathways, the consideration of AI technologies might be useful for CARICOM.
- Telepresence robotics, which is increasingly incorporating AI components, has particular utility for disabled or special needs students. Such technology allows for continued learning even in cases of emergencies or crises since it allows students who are unable to attend school to still be educated at home or even in a hospital. Such technology can be leveraged by CARICOM to ensure inclusive access to education.
- The 'Simpler Voice: Overcoming Illiteracy' IBM Project uses AI to help illiterate adult learners or those with low literacy levels. It translates texts while providing a basic definition through verbal and visual aid. In member states with low literacy rates this technology could potentially break barriers.
- AI technologies can also be used to automate administrative tasks such as grading and processing applications. While machines have already been used to grade multiple choice tests, reports suggest that soon AI technologies may be capable of assessing written responses. This would allow teachers more time to focus on their students.

Ethical Considerations

Where AI technologies are used for administrative tasks such as accepting or rejecting student applications, concerns about unfair discrimination can arise. Where such technologies use large concentrations of data from students and teachers privacy risks will become a concern. Furthermore, in cases where AI-generated decisions meant to guide a student's learning process are wrong then liability becomes an issue. The question of emotional intelligence and the capacity of these technologies to extend such especially within a diverse context like the classroom is also an equally important concern.

Box 3. : The Potential Utility of AI in the Caribbean's Educational Sector – Source: Author's compilation using information from United Nations Educational, Scientific and Cultural Organization (2019); CARICOM (2017).

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The examples in Boxes 1,2 and 3 should not be viewed as a list of exhaustive applications, especially when considering the far-reaching nature of AI across a vast number of sectors worldwide. Rather, they simply serve as thought-provoking suggestions to encourage further research on potential applications of AI in the Caribbean. However, despite the potential that these technologies may hold, especially as it relates to solving some of the region's ongoing developmental challenges, findings from the Oxford Government AI Readiness Index suggest that Caribbean governments are not necessarily well placed to take advantage of the benefits deriving from AI technologies - evident by their low rankings in Table 4. Considering that these results are compiled to capture a government's current capacity to use AI technologies based on existing governance frameworks, infrastructure and data, skills and education, and government and public services, then the region's low results are reflective of the need for improvement in these areas.

COUNTRY	RANK	SCORE
Trinidad & Tobago	73	5.038
Jamaica	87	4.476
The Bahamas	133	2.527
Barbados	135	2.430
St. Kitts & Nevis	142	2.230
Dominica	143	2.191
Antigua & Barbuda	144	2.099
Guyana	145	2.094
St. Vincent & the Grenadines	149	2.052
Haiti	150	2.034
St. Lucia	153	1.091
Suriname	155	1.769
Grenada	164	1.086
Belize	171	0.745

Table 4. Government AI Readiness Index – Source: Author's compilation using data from Oxford Insights and International Development Research Centre (2019).

Moreover, recognizing that this Index captures only the government's capacity, it begs the question as to whether the adoption of AI technologies should be championed by the government or by the private sector. If the response is government, then the limited adoption of even the most basic emerging technologies by the region's governments (see Table 5) is problematic. Whereas, if it is the private sector, then the observed lack of a dynamic and innovative private sector across the region (Ruprah and Sierra, 2016) becomes a major obstacle in this regard. However, it is more constructive to consider the role that both entities must play. Governments must not only lead by example in their adoption of emerging technologies, but must also ensure that the necessary frameworks are developed and enforced to allow full utilisation of such technologies by the private sector, who too must develop an innovative appetite. When considering the reported weak links between the private sector and universities, research centres, laboratories or even other companies in the same sector (Dohnert, 2017), fostering greater collaboration could greatly assist in making the region's private sector more innovative.

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COUNTRY	RANK / 143	SCORE (1-7 BEST)
Guyana	89	3.6
Jamaica	94	3.5
Trinidad & Tobago	96	3.5
Barbados	101	3.5
Suriname	133	2.7
Haiti	140	2.5

Table 5. Government ICT Usage - Author's compilation of data from World Economic Forum (2015) - Note that for other CARICOM countries no data was available.

Evidently then, based on the overall findings and recognizing the significant data constraints under this perspective, the current application of AI systems and technologies across the region appear limited, but potential for significant uptake is also evident, especially if measures are taken to improve the region's AI readiness through government action.

AI-related Policy

The potential benefits of AI can be quickly eroded if society is not protected from adverse associated effects, much like those mentioned under the ethical considerations in Boxes 1,2 and 3. Some of the considerations identified include invasion of privacy, job loss, bias, serious injury or even death, among other issues. Such important societal concerns signal the need for regulation, but in an innovation-driven field like AI, some argue that precautionary regulation at early stages can hinder future development. While compelling arguments exist for no regulation, especially in initial stages, in no instance should they be used to negate the government's role in protecting society. Rather, Dawson (2017) proposes a change in terminology from 'regulation' to 'policy'- noting the flexibility and pro-innovative attitude associated with the term 'policy', compared to the restrictive perception evoked by the term 'regulation'. Here, AI-related policy refers to public policies which aim to maximize the benefits of AI technologies, while simultaneously minimizing potential risks (Dutton, 2018). For policymakers however, the challenge at hand lies in the ability to understand a constantly developing field like AI in such a way that allows effective policies to be developed. This observed knowledge deficit at governmental levels worldwide is owed largely to the concentration of AI development and expertise in a few select organizations (Dawson, 2017).

On the global scene, an uptake in the development of AI-related policies and strategies has emerged (see Figure 4). Areas such as basic and applied research, ethics, inclusion, data and digital infrastructure, industrialization of AI technologies, future of work and skills, AI use in government, and others are being increasingly addressed in different national AI policies and strategies (Dutton, 2018). However, at present, no Caribbean state has developed any AI-related policy nor has public intention to do so been announced. While most Caribbean economies have developed broad ICT policies and strategies throughout the years, very few have developed targeted policies specifically addressing aspects of the digital economy. In fact, it was only recently that Trinidad and Tobago

developed and launched a National E-commerce Strategy (Republic of Trinidad and Tobago Ministry of Trade and Industry, 2017). Apart from that, issues like e-commerce, digital trade, AI and others, are broadly addressed policy-wise under the banner of ICT. Absent an official strategic approach or policy towards AI at both national and regional levels, ongoing buzz is driven largely by educational seminars and conferences which tend to focus on the area of future work and skills. For examples of such, consider the "Artificial Intelligence – the Future of Accounting" conference hosted by the Institute of Chartered Accountants of Trinidad and Tobago; or the "Artificial Intelligence and Educating for Tomorrow" open discussion hosted by the UWI Mona Campus' Faculty of Science and Technology. Such informational sessions directly speaking towards AI appear to be gaining popularity in the Caribbean.

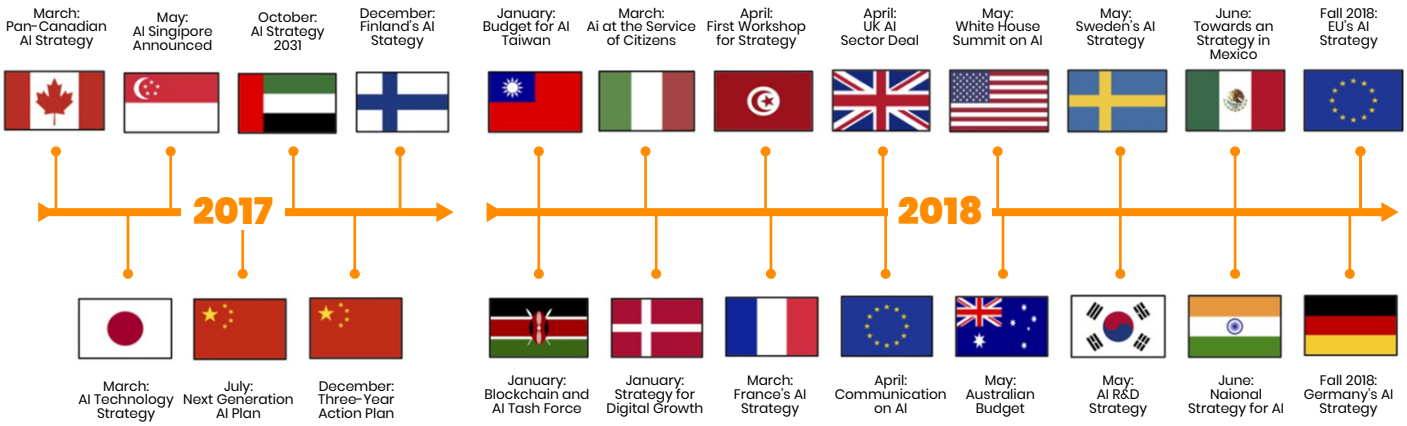

Figure4. AI Strategies & Policies by Governments Around the World - Source: Dutton (2018).

The Caribbean's observed silence regarding either regional or national AI policies or strategies may be owed to several factors including limited resources, low priority interest and a reactive attitude. Battling the region's infinite needs with finite resources highlights a scenario of competing interests among a crowded policy space, which makes it difficult to divert attention towards areas considered to be of low priority. Nevertheless, recognizing the potential that AI holds for the Caribbean it should not be considered as low priority. However, with the Caribbean positioned to be a net importer of AI technologies it is not unusual for the region to adopt a reactive approach, as seen in previous cases where rules were shaped by the Global North. This must not become an excuse for the Caribbean to preclude itself from initiating AI-related policy discussion or participating in global debates. Rather, recognizing that AI in the Caribbean remains confined to nascent stages provides a unique opportunity for exploring what actually needs to be discussed policy-wise, especially when considering that once such technologies are implemented the region becomes subjected to the same ethical and legal issues being discussed globally.

Drawing from the overall findings under this subheading, AI-policy discussion remains either very limited, with the occasional mention in broader ICT policies, or non-existent in some cases. However, it may gather momentum as global attention towards this area increases.

3. Section 1: Summary Findings

The analysis in Section 1 reveals that AI is still a very nascent field in the Caribbean. Under all three perspectives (R&D, application and policy) there are very limited levels of engagement.

- Regarding AI R&D, there is limited existing research. Private sector financing and FDI appear necessary for the development of AI research centres. The existing academic framework at the UWI provides a basis for the development of AI R&D and with greater private sector collaboration it could be pivotal in advancing research in this field.

- Concerning current AI application, without data it is difficult to ascertain the region's actual utilisation of AI technologies. However, what is conclusive is the potential utility of such technologies for solving some of the region's ongoing developmental challenges. Presently, different governments have displayed varying levels of readiness as it relates to the exploitation of AI's benefits, with Trinidad and Tobago ranking the 'most prepared'.

- As it relates to policy, there are no regional or national AI-related policies or strategies, but there appears to be a growing number of informational seminars and sessions focused on aspects like the future of work and skills in an AI context.

Overall, AI in the Caribbean currently remains confined to initial stages.

4. Section 2: Conceptualizing ethical considerations of AI in The Caribbean

If the Caribbean is to truly harness AI's benefits, discussion must not focus solely on applications but must also address related ethical concerns. In Section 1, Boxes 1,2, and 3 hinted at some potential ethical issues arising from the widespread adoption and use of AI technologies in different sectors. According to the World Economic Forum (2016), the top nine ethical issues associated with AI include:

- Unemployment – increasing fears of job loss due to increased automation and the use of robots;
- Inequality – the potential for AI technologies to create an increasing wealth divide;
- Humanity – particularly the implication of machines on human behaviour and interaction;
- Artificial stupidity – the possibility of intelligent technology making mistakes;
- Racist robots – the generation of biased outcomes with discriminatory effects;
- Security – the importance of cybersecurity and data protection;
- Evil genies – the possibility of unintended consequences which may be as extreme as rogue AI;
- Singularity – the ability to retain human control over such complex systems;
- Robot rights – the 'humane' treatment of AI bots.

Certainly, each of these identified areas raises some important societal concerns, which if not appropriately addressed can erode any potential benefits that the application of AI technologies may yield. This section discusses three of these ethical considerations within a Caribbean context. These include unemployment fears due to increased automation and use of intelligent robots, biased outcomes in AI and the implications of AI's data requirements on privacy and data protection.

Addressing Unemployment Concerns Related to AI in the Caribbean

The impact of AI on job security remains one of the most popular ethical concerns, with growing fears that increased automation will yield significant job loss and destroy lower incomes, subsequently having negative implications for national income equality goals. In the Caribbean, although the present uptake of AI technologies appears limited, concerns of the impending impact on unemployment have already been voiced in local news outlets. For example, in Barbados, General Secretary of the Barbados Workers' Union (BWU) Senator Toni Moore, noted the possibility of some workers being displaced as a result of job loss from AI technologies and digital transformation (Madden, 2019). Likewise, in Jamaica, Dr Noel Brown Head of the School of Engineering and Associate Professor at the University of Technology, noted that about 20% of jobs will be eliminated by the use of AI in Jamaica (Williams, 2018). Evidently then, even at such initial stages there is a growing level of awareness surrounding AI and its associated unemployment concerns for the Caribbean.

According to the Inter-American Development Bank (2018), the risk of job loss due to AI can vary between 10-65%, but the forecasted impact for Latin America and the Caribbean (LAC) lies in the middle of the spectrum at 36-43%. Wholly transposing these predictions to the Caribbean's reality might be problematic, especially when considering that findings from LAC studies are often more reflective of Latin American countries. Subsequently, actual predictions for the Caribbean could potentially be even higher. Nevertheless, what is conclusive is the potential for AI

technologies to drastically change workplace environments across the Caribbean. Undoubtedly, AI, like all other technological advancements will eliminate several jobs but what remains understated is the many new jobs that will be created. By 2022, despite the displacement of 75 million jobs it is expected that AI technologies will create 133 million new roles, yielding a net effect of 58 million new jobs (World Economic Forum 2018 and Chowdhry 2018). Such a process can be theoretically framed within Schumpeter's theory of creative destruction which postulates that "the process of industrial mutation incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one" (Schumpeter, 1942). Otherwise explained, innovation, while destroying established firms, products and jobs, simultaneously creates new industries, sources of wealth and employment (Dodgson and Gann, 2010). Thus, amidst technological disruption human beings will adapt to productivity improvements and find new ways to complement these technologies, a process from which improved standards of living should follow (Deutsche Bank Research, 2018). Recognizing this, the conversation should change from a focused fear on job loss towards equipping the current workforce with the skills needed to take advantage of these new jobs. Additionally, without knowing how many of these new jobs may "automatically" come to developing countries, it is important that developing countries position themselves to be the home for such jobs. This will require structural changes to existing infrastructures and continued retraining of the workforce. Such a perspective has already been voiced by Senator Toni Moore[9], who expressed the need to retrain and retool for the AI world rather than resist change (Madden, 2019).

Successful navigation of AI-driven work environments will depend largely on an employee's digital skills and competencies. The United Nations' Educational, Scientific and Cultural Organization (2019) proposed a framework of digital literacy competency areas that are necessary for a digital and AI-powered world. Some of the highlighted competency areas included fundamentals of hardware and software, information and data literacy, communication and collaboration, digital content creation, safety, problem solving, and career-related competencies (knowledge of specialized hardware/software for operating in a particular field such as engineering). The question then, is whether the Caribbean's workforce is equipped with such skills. While it may be difficult to ascertain the availability of competencies in these exact areas, measurements of individual ICT usage (Table 6) and digital skills among the active population (Table 7) can be used as proxies to gauge the region's level of digital literacy. Drawing from the results in Table 6 and 7, what is evident is the lack of data in this area, which is not surprising when considering that the United Nations' Educational, Scientific and Cultural Organization (2019) noted the global need for data to be collected in order to develop a global framework for measuring digital literacy. Additionally, there is an observed disparity in the endowment of digital skills across the region based on existing data. Countries like Trinidad and Tobago, Barbados and Jamaica, appear to have higher digital literacy rates than other member states for which data is available. Yet even within these countries there is still a need for the continuous development of digital skills so that existing rankings can be improved.

9 *General Secretary of the Barbados Workers' Union (BWU).*

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COUNTRY	RANK / 143	SCORE (1-7 BEST)
Barbados	40	5.2
Trinidad & Tobago	58	4.5
Suriname	83	3.4
Jamaica	84	3.4
Guyana	107	2.6
Haiti	131	1.9

Table 6. Individual ICT Usage - Source: Author's compilation using data from World Economic Forum (2015). Note that for other CARICOM countries no data was available.

COUNTRY	RANK / 140	SCORE (1-7 BEST)
Trinidad & Tobago	54	4.4
Jamaica	79	3.9
Haiti	136	2.8

Table 7. Digital Skills Among Active Population - Source: Author's compilation using data from World Economic Forum (2018). Note that for other CARICOM countries no data was available.

Whose responsibility is it to ensure that the workforce is equipped with such skills? Retraining and retooling must begin from as early as the educational stage. In other words, educational systems and learning must evolve to match the needs of a changed workplace. While there are currently pockets of technological involvement in the region's educational system, it is not sufficient to ensure that graduates develop the skills needed for the 21st century economy and society (Madden, 2019). According to Dr. Warren Smith, President of the Caribbean Development Bank (CDB), the region risks falling behind due to low enrolment levels in STEM (science, technology, engineering and mathematics) subjects which are becoming increasingly important for the future jobs likely to be created by the proliferation of AI, cloud computing automation and other technologies (CARICOM Today, 2019). Dr. Smith highlighted that for the Caribbean such jobs may include innovation professionals, artificial and machine learning specialists, robotics and software engineers, data analysts, and social media experts, among others (CARICOM Today, 2019). Evidently then, Caribbean governments must transform the education system in such a way that it adopts a life-long learning approach towards the development of digital skills (Madden, 2019; Williams 2018; and Kuroda, 2019). The onus is also on the private sector to drive training. In fact, studies show that 39.3% of job seekers consider growth and training opportunities as important aspects when evaluating job prospects – a statistic that is likely to significantly increase as more millennials enter the workforce (Hearn, 2017). Organizations interested in capturing and retaining the best talent will need to provide avenues for the consistent training and development of their employees. Indeed, industry-wide retraining initiatives can also be developed. Consider the example set by the Institute of Charted Accountants of Trinidad and Tobago (ICATT) which hosted a conference to discuss the future of Accounting in light of AI technologies. For sectors highly susceptible to AI disruption and which are relevant to all member states, such as tourism, regional approaches can be developed towards the retraining of the workforce, especially through private-public partnerships where governments can reach out to experts from Google, Facebook, and Microsoft, among others to provide practical

training. Retraining and retooling for the AI world is not a developing country only problem. In fact, developed and advanced economies like Australia are investing up to USD 250,000 in retraining efforts (Organisation for Economic Co-operation and Development, 2019).

Evidently then, while the adoption of AI technologies poses a threat to job security it also yields benefits like the creation of new jobs with the potential for improved standards of living. The ethical concern therefore should not lie in resisting the proposed change but rather, in ensuring that both governments and firms take the necessary measures to equip the workforce with the skills needed to take advantage of these new opportunities. Considering that AI is currently in its initial stages in the Caribbean, the region has the unique opportunity to anticipate and better prepare for these changes as they come in order to avoid massive displacement and its subsequent implications.

Resolving Ethical Concerns Stemming from AI's Data Requirements

Similar to the human body's need for food in order to survive, AI and subsequent developments in this field depend largely on data. This dependency relationship stems from the use of algorithms[10] by AI, which enables these systems and technologies to execute specific tasks by translating input data into output. Thus, data forms the very foundation of AI's development and application. However, the need for quality data and unfettered access to such by AI technologies raises certain ethical concerns – two of which are examined within this section. These include the issue of biased outcomes and data protection concerns.

1. Mitigating Biased Outcomes in AI

Understanding how AI and machine learning algorithms use data can be a rather complex issue for non AI experts. Recognizing this, the European Union Agency for Fundamental Rights (EU FRA, 2019) developed a simplified illustration of the types of data used by algorithms within AI technologies and systems (see Figure 5). Typically, these algorithms use at least three main datasets, notably, training data – which is initially used to build the algorithm; input data – which is the data fed to the algorithm; and output data – which is the result produced when the input data is fed to the algorithm (EU FRA, 2019). Evidently then, the outcomes generated by AI systems and technologies are driven by datasets. Therefore, "any development or application of AI can only be as good as the quality of the data collected and used" (Sunblad, 2018), especially when considering the Garbage-In, Garbage-Out (GIGO) constraint which dictates that flawed input data will produce flawed output (Christensson, 2015). Following this logic, in cases where substandard training and input data are used substandard outcomes should be expected, but the situation becomes even more concerning when such outcomes have serious ethical implications. For evidence of such, consider Amazon's AI-powered

10 Algorithms can be loosely defined within this context as a sequence of instructions.

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recruiting tool which showed bias against women (Dastin, 2018). How about the Correctional Offender Management Profiling for Alternative Sanctions (COMPAS), an AI-driven tool used to predict recidivism, which was incorrectly labelling African-American defendants as "high risk" at almost twice the rate that white defendants were mislabelled (Angwin et al., 2016). What about findings that AI facial recognition systems work better for white men than black women (Buolamwini and Gebru, 2018). Better yet, what about the scenario where Microsoft's online chat-bot became racist in a matter of hours (Victor, 2016). Notice that in all four cases the biased outcomes produced had discriminatory effects, capable of exacerbating existing inequalities. What the EU FRA (2019) found as the main contributor was the data used to train these systems. In fact, Silberg and Manyika (2019) note that often in cases of biased outcomes the underlying data rather than the algorithm itself is often the problem, further highlighting that bias can be introduced into data through poor data collection techniques and feedback loops resulting from data generated by users.

Figure 5. Simplified Illustration of Data Used by AI and Machine Learning Algorithms – Source: Adapted from EU FRA (2019). For the full illustration with examples, see source.

Evidently then, directly addressing identified data issues is a potential avenue for tackling bias in AI technologies. Typically, researchers in this area suggest enforcing "fairness"[11] constraints on AI models, and while many approaches for this exist the most prominent include: (i) pre-processing techniques which aim to maintain as much accuracy as possible within the data; (ii) post-processing techniques which involve changing some of the predictions to satisfy fairness constraints; and (iii) "either imposing fairness constraints on the optimization process itself or using an adversary to minimize the system's ability to predict the sensitive attribute" (Silber and Manyika, 2019; Calmon et al., 2017; Hardt et al. 2016; Zhang et al., 2018; and Agarwal et al., 2018). Certainly, researchers appear to be making technical progress in this field but much more is still needed if bias is to be effectively eliminated.

Silber and Manyika (2019) also note the relevance of operational procedures such as improved data collection techniques and the use of internal review teams or third parties to proactively audit data in order to guard against bias. These practical efforts can be viewed as filtering mechanisms aimed at ensuring that quality data is collected and used. This then begs the questions of what exactly is quality data? With limited global research in this area several countries continue to struggle with varying definitions of quality data. To complicate matters further, the rise of Big Data has been accompanied by a false sense of security where findings from large datasets are automatically considered to be accurate. However, McFarland and McFarland (2015), caution that hidden biases in large datasets can be easily overlooked "due to the enhanced significance of the results created by the data size." Additionally, the EU FRA (2019)

11 "Fairness in itself is a very subjective concept which is difficult to measure. With more than 21 different definitions of fairness, codifying the concept becomes complicated and will often involve trade-offs between various definitions and between fairness and other objectives." (Silberg and Manyika, 2019).

emphasizes that within the context of AI, data quality encompasses a much broader scope than simply discussions on accuracy. Rather, when assessing data quality great attention must be paid to whether the data is fit for purpose. According to Cai and Zhu (2015), data which conforms to the relevant uses and meets the intended requirements can be considered fit for purpose and consequently 'good-quality' data. In proposing a quality criterion, particularly useful in the context of Big Data, Cai and Zhu (2015) propose a hierarchal data quality standard which outlines useful data quality dimensions and indicators. The highlighted dimensions and indicators include: availability (accessibility and timeliness), usability (credibility), reliability (accuracy, consistency, and integrity), relevance (fitness) and presentation quality (readability). Another approach lies in understanding the sources of error related to data quality and putting measures in place to avoid such. The EU FRA (2019) considers measurement and representation errors to be the two most common sources of error impacting data quality, especially in the context of classical survey research. Therefore, deliberate efforts to guard against such errors during data collection processes and analyses can greatly assist in improving data quality.

The Caribbean is often considered "data poor" not only due to gross insufficiencies of data but also because available data are not disseminated widely nor in a timely manner (Abdulkadri et. al., 2016). While this situation would appear challenging for the successful application of AI technologies and potentially be conducive for the generation of biased outcomes, it could also be viewed as an opportunity to refine and improve data collection techniques to better meet the needs of these technologies. The EU FRA (2019) proposes some guiding questions which can be used to aid Caribbean governments, statistical agencies and private firms, in their data collection or data purchase efforts. Some of these include:

- Where is the data sourced from – particularly who is responsible for its collection, maintenance and dissemination?
- Is the data appropriate for the algorithm's purpose? – this may require some level of collaboration between the algorithm's designer and the data collector.
- Can the data be considered representative? – in other words which groups are under-represented and which groups are over-represented? Preventing either scenario will require more cognizant sampling techniques.
- How accurate is the data and is important information missing that could produce skewed results?
- What is the geographic reach and timeline of the collected data and does it match the needs of the AI application?

Certainly, this is not exhaustive checklist but rather a suggestion of some the right questions that should be asked when collecting or using already collected data, in order to ensure that the data itself is not inherently introducing bias into the algorithm's outcome.

Evidently, findings from this subsection underscore the importance of data and its quality in the successful application of AI technologies. Failure to recognize this relationship can lead to increasing cases of biased outcomes by AI technologies with far reaching ethical implications. Recognizing the significant data constraints in the Caribbean signals the need and opportunity for increased data collection efforts to be guided by refined data collection techniques which aim to mitigate bias from the onset.

2. The Battle Between Data Openness and Privacy

In order to function AI requires significant data volume, variety and veracity (European Data Portal, 2018). In fact, when considering that the "intelligence" component of AI is developed through learning from large quantities of high-quality data, it contextualizes the importance of access to open data in unlocking the full potential of AI applications (European Data Portal, 2018). Policymakers have increasingly underscored the importance of making data available for AI, noting that access to large bodies of data is a competitive advantage within itself for countries and companies within the global AI race (New, 2019). Open data refers to data that anyone can use, access and share. Therefore, "for data to be considered open, it must be published in an accessible format with a licence that permits anyone to access, use and share it" (Open Data Institute, 2015). While open government data policies are becoming increasingly popular, New (2019) notes that government data represents

only a fraction of the data which is potentially useful for AI development, highlighting that utility can also be derived from the opening of data collected by private sector entities and non-profit organizations. Recognizing such, France, in its attempts to become a leader in AI, rolled out an ambitious AI strategy which included developing an open data policy that proposed both the opening of government data and certain data held by private entities on a case-by-case basis, with increased support for the right to data portability (Villani, 2018). Through what some are considering as one of the most ambitious open data policies, France intends to boost data sharing in order to create data in the public interest which can be fully utilized by AI technologies.

In various parts of the world, open data is being used to boost AI research and practice. Consider for example, the AI pilot project in the United States of America (USA) which utilized open data to aid in crime prevention – this project is also being adopted by the United Kingdom (Policy Connect, 2020). Another example can be found within Michael Kratsios'[12] statement that the Federal Government is committed to releasing any data that could advance AI research in the USA; and France, as already discussed, is adopting an ambitious approach towards the release of data for AI. However, in the Caribbean the situation is drastically different. Already suffering from gross insufficiencies of data, Abdulkadri et. al. (2016) further highlight that where data may be available across the region, it is not often widely disseminated. In line with such, Table 8 confirms extremely low levels of data openness for Caribbean countries. According to findings in the Open Data Barometer (2017) Fourth Edition Report, which assessed four CARICOM countries[13], there is a lack of government action to open data. The report found that the region relies heavily on external financial and technical support to foster open data initiatives but their sustainably and further development is often negatively impacted by changes in government administration. Furthermore, countries like Jamaica, which would have recently launched open data portals are still falling behind in their attempts to make government data open. The report cited the lack of a systematic process for providing consistent updates as the main reason for this. So even with the existence of open data portals the content when examined is often incomplete and outdated. As a result, the opportunities offered by open data are not yet available to the region's private sector. Consequently, limited amounts of open data are likely to hinder the region's ability in unlocking the full potential of AI, signalling the need for improvements in this area.

COUNTRY	SCORE
Jamaica	26%
Trinidad & Tobago	21%
Guyana	20%
The Bahamas	17%
St. Lucia	15%
St. Vincent & the Grenadines	7%
Antigua & Barbuda	5%
Barbados	4%
St. Kitts & Nevis	4%

Table 8. Global Open Data Index – Source: Author's compilation using data from Open Knowledge Foundation (2016) – Note data is not available for all Caribbean countries.

12 President Trump's chief technology advisor.

13 Jamaica, Trinidad & Tobago, St. Lucia and Haiti.

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In highlighting how governments can promote open data, Chui, Farrell and Jackson (2018) note the unique opportunity for governments to serve as an "open-data provider, catalyst, policymaker and user". As an open data provider, government should seek to capture information electronically, release data publicly and frequently and identify ways to improve data quality. In its role as an open data catalyst, government must champion the movement towards building an open data culture while including as much stakeholders as possible. Within its capacity as policymaker, government must establish systematic procedures and standards for ensuring data quality and for providing consistent updates. Regarding the government's status as a user, it is expected that not only private entities but also governments can benefit from the opportunities presented from the use of open data, particularly in their decision making and accountability aspects. Certainly, these recommendations provided by Chui, Farrell and Jackson (2018) could be used to develop and mobilize open data initiatives for the Caribbean in order to ensure greater availability and access to high-quality data. At present, there is no regional framework under the auspices of CARICOM speaking to regional open data initiatives. In 2016, the Caribbean Telecommunications Union made a presentation[14] on advancing Caribbean Open Data through a Caribbean Open Data portal but since then no actions appear to have been mobilised (Lewis, 2016). Therefore, apart from the CARICOM's Regional Strategy for the Development of Statistics (RSDS) 2019-2030 which is pushing for the greater collection of regional data, matters related to data, its collection, use, and accessibility (CARICOM, 2018) are handled nationally. At national levels, the World Bank conducted Open Data Readiness Assessments for Antigua and Barbuda, St. Lucia and Jamaica and supported the development of Open Data portals in both St. Lucia (https://data.govt.lc/) and Jamaica (https://data.gov.jm/) (World Bank, 2017). Other countries that appear to have Open Data portals include Trinidad and Tobago (https://data.gov.tt/), Haiti (http://opendata.investhaiti.ht/), Montserrat (https://gisdataportal.gov.ms/) and Suriname (https://data-surinameonline.opendata.arcgis.com/). However, consistent with the findings of the Open Data Barometer (2017) Fourth Edition Report, as previously highlighted, information on these systems are often incomplete and outdated, signalling the need for further improvements.

While the need for improvements to data accessibility are evident, there are certain privacy implications to consider. Bernhard Debatin[15] points out that the concept of privacy has changed overtime, with data protection and privacy becoming central components in post-modern information societies (Forbes Insights, 2019). As advanced technologies emerge against the backdrop of data scandals like Cambridge

14 This presentation was made at the LEaders Activating Research Networks (LEARN) Workshop in Port-of-Spain, Trinidad and Tobago, November 24, 2016.

15 Bernhard Debatin is a professor and director of the Institute for Applied and Professional Ethics at Ohio University.

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Analytica, Facebook, Google+ and others, individuals are in theory becoming more concerned about how companies use their data. Conceptualizing this privacy concern within a theoretical sense draws attention to the privacy paradox which speaks to a scenario where individuals although claiming to be very concerned about privacy, adopt very little measures to protect personal data (Barth and Jong, 2017). However, as the concept of privacy becomes increasingly complex and lengthy user agreements become more popular, consumers hastily accepting terms and conditions often do not understand what privacy rights they are giving up (Forbes Insights, 2019). Therefore, there should be a sense of obligation whether on the part of governments, firms, or both to ensure that the fundamental right of privacy is not eroded as advanced technologies make concepts increasingly difficult for consumers.

On the legislative front, countries are drafting new data protection laws to ensure that data protection and privacy are maintained, especially with the emergence of new data-driven technologies. Consider for example the USA's Future of AI Act, a federal bill introduced in the Senate during 2017[16] which aims to protect the privacy rights of individuals particularly against potential abuses from AI. On a broader scale, the European Union introduced its General Data Protection Regulation (GDPR) which aims to strengthen data protection and privacy across the European Union in all aspects. In CARICOM only at least 7 of the 15 member states have existing data protection legislations which in some cases have not been fully enacted. Furthermore, for those member states with enacted data protection legislations, concern resides in the ability of these legislations to effectively regulate privacy and data protection in the digital realm given their dated nature in some respects. Additionally, while the obligation may exist, enforcement of legislation remains challenging across the region. Therefore, existing laws need to be both strengthened and updated and effective enforcement mechanisms also need to be implemented. When modernizing such laws, guidance should be taken from in-depth research on not only how technological innovation is currently impacting traditional constructs of privacy but also future implications in order to increase the law's flexibility. Model policy guidelines and legislative texts have also been developed for the ICT market in the Caribbean under the HIPCAR (Harmonization of ICT Policies, Legislation and Regulatory Procedures in the Caribbean) project, led by the International Telecommunication Union (ITU) and other partners (ITU, 2013). Guidelines and model legislative texts for regulating privacy and data protection are included within the HIPCAR project and could be used by CARICOM Member States to update existing legislation. For those CARICOM Member States lacking data protection

16 Note that since 2017 there has been little movement on this Bill.

and privacy legislation, the development of such will be important if privacy and data protection are to be effectively preserved in the digital age. Beyond legislative action, consideration can also be given to privacy-preserving techniques. Data trusts for example, represent an innovative potential solution that strikes the balance between increased data access and privacy preservation. In short, by providing independent stewardship of data, data trusts render third-party users responsible for ensuring that data is used and shared in a fair, safe and equitable manner (Free and Wells, 2019). Evidently then, the region should not feel confined to tackling this issue only from a legislative standpoint but can also consider more innovative solutions.

Drawing from the overall discussion in this subsection, advances in AI appear to be pointing countries towards an open data culture. However, while this may be ideal for AI it also raises concerns regarding the potential impact on data privacy and protection. Therefore, not only must the Caribbean aim to increase the quantity, quality and accessibility of its data but it must also guard against privacy risks, by ensuring that the privacy rights of individuals are still maintained even as technological advances emerge.

5. Section 2: Summary Findings

The adoption of AI raises a number of important societal concerns with far-reaching ethical implications. As it relates to growing unemployment fears, retraining and retooling must become a priority if the Caribbean is to develop a workforce capable of transitioning towards newer technology driven jobs. This requires a transformation of the region's education system to better meet the needs of the 21st century, and a conscience effort by the private sector to ensure continued training in new areas for employees.

Recognizing the potential for AI technologies to exacerbate existing inequalities through the generation of biased results, it is imperative that the region improves its data collection efforts. When assessing data quality, emphasis should be placed on dimensions such as availability, usability, reliability, relevance and presentation quality. Additionally, data collection techniques should also be framed with the purpose of the data in mind, which may require a collaborative effort between those responsible for the design of the algorithms and those for data collection.

Regarding the battle between data openness and privacy, the emergence of AI must not erode an individual's fundamental right to privacy. While the concept of privacy becomes increasingly complex especially in the digital age, it is necessary for the Caribbean to update existing legislative frameworks to ensure that data protection and privacy are maintained. Beyond legislative action, the region can also actively engage in the development of innovative solutions aimed at increasing data access while still preserving privacy.

Although this section only addressed three issues, it is important to note that there are many other ethical risks associated with AI which the region must still be prepared to face.

6. Conclusions & Recommendations

In the Caribbean, AI can still be considered a very nascent field. AI-related R&D is limited, application of such technologies based on data where available is minimal and AI-related policy is practically non-existent at both national and regional levels. However, recognizing the potential that these technologies hold for improving the Caribbean's situation and solving some of the region's ongoing developmental challenges, it is likely that greater attention will have to be paid to this area. Furthermore, with AI poised as the next digital frontier, an increasing number of the region's digital transformation plans are likely to include AI-related components. However, based on the region's overall low rankings in the Oxford Government AI Readiness Index, it is evident that Caribbean countries must begin preparations from now in order to better position themselves to take advantage of these opportunities. Below are a few recommendations aimed at supporting the development of AI in the Caribbean beyond its initial stages.

- Regarding the advancement of AI-related R&D, lessons can be drawn from Germany's approach which aims to streamline research findings into application through new research centres, funding for cluster development and Franco-Germany research cooperation (Organisation for Economic Co-operation and Development, 2019). Likewise, CARICOM can consider adopting a regional approach towards its research efforts in this field, utilizing perhaps the UWI as a research base, while simultaneously seeking out funding for various projects is this area. Additionally, it will be important for any established research centre or group to collaborate closely with the region's private sector in attempts to pursue a comprehensive transfer of research findings into application.

- While a variety of measures need to be adopted in order to increase the uptake of AI, a starting point would be to analyse the metrics used to compile the Oxford Government AI Readiness Index, where the region's rankings were relatively low (see Table 4). These metrics included analyses of existing governance frameworks, infrastructure and data quality, availability of skills and education, and the adoption of technologies in government and public services. Improvements in these areas will be critical for developing a compatible ecosystem, capable of successfully leveraging AI technologies.

- As it relates to promoting AI based policy, this can be championed by the region's academics, who have an intrinsic responsibility to draw public awareness to different subject matters. By creating public buzz about the policy implications for AI technologies, academics can capture the attention of the relevant policy makers and high-level officials which are needed to start formal dialogue in this area.

While the above only serves to provide an idea of some practical recommendations, it should not be taken as an exhaustive list or a concrete action plan. Developing a national or even regional AI strategy or roadmap would be the ideal course of action, but given the preliminary stages of AI in the Caribbean, it may be more useful to consider tangible ways of first increasing the visibility of this field in the region.

On the ethical front, the Caribbean is not immune to the important societal concerns that AI technologies are raising. Although this paper's discussion focused solely on the ethical concerns stemming from job displacement effects, biased outcomes and data privacy

concerns, there are many other questions that the region must be prepared to face. For example, where should liability be assigned in cases of unintended consequences; or who would own the copyright on content created by AI, particularly in legal regimes where protection covers only human-created content? These are just a few of the thought-provoking questions that the region must prepare itself to address, even if at the moment AI appears to be a distant technology. Rather lessons can be drawn from Norway, which in preparation for the disruptive effects of AI technologies, has developed a skills-reform programme called "Learning for Life" which aims to develop an AI-skilled forced. Positive still has been Canada's efforts within its Pan-Canadian AI Strategy to spearhead global thought leadership on the ethical, policy, social and legal implications of advances in AI (Organisation for Economic Co-operation and Development, 2019). Evidently, these "softer aspects" of AI are receiving increasing global attention and should not be ignored by the region especially when considering their far reaching implications.

While this paper has not addressed all of AI's potential applications and ethical considerations for the Caribbean, it sought to generate discussion with the intent of bringing increased regional visibility to the field of AI. Therefore, it is hoped that future work capable of better positioning the region to take advantage of the benefits that AI holds, will be developed.

Annex 1

This Annex contains a compilation of courses and research worked related to AI, which are or have been conducted at the University of the West Indies Campuses. Note that this analysis does not include the Open Campuses. The information was compiled from course outlines and research work publicly available on the University of the West Indies' website (UWI, 2020). It should not be taken as an exhaustive list, especially when considering the outdated nature of some of the website's information and the fact that some courses may address AI and related components without explicit mention in course outlines. Therefore, this table should merely be used as a guide to provide readers with an understanding of the existing framework under which AI R&D can be encouraged and developed at the UWI.

CAVE HILL CAMPUS – BARBADOS			
RELATED ACADEMIC PROGRAMME	**FACULTY**	**COURSE CODE**	**DESCRIPTION**
	Social Sciences	FINA 2003 – Information Technology for Banking and Finance (Undergraduate)	Provides an understanding of emerging technologies in the finance industry, with coverage of computer systems, data security, systems development, IT applications in banking and finance, hardware and operating system, and information processing.
		BUSA 6003 - Data Mining I: Supervised learning & BUSA 6004 - Data Mining II: Unsupervised learning (Postgraduate)	Explores the sophisticated methods and algorithms of supervised and unsupervised learning and is designed to equip graduates with the knowledge and skills needed to understand, analyse and derive insights from vast stores of digital information assets. Topics covered include: decision trees, support vector machines, neural networks, naïve bayes, ensemble methods, and kernel methods, clustering, anomaly detection, factor analysis, and dimensionality reduction.
		EGOV 6030 – Legal & Ethical Issues in e-governance (Postgraduate)	No available course description online.
	Medical Sciences	MDSC2011 - Technology Applications in Healthcare (Undergraduate)	No available course description online.
	Humanities & Education	EDTK3304 - Media and Technology in Education (Undergraduate)	No available course description online.
		EDCU 6300 - Curriculum Design for Caribbean Settings Part II- Integrating Media & Technology (Postgraduate)	No available course description online.
	Law	LAW3765 – Law, Technology & The Internet (Undergraduate)	Examines the legal issues arising from emerging technologies. It focuses on aspects of the internet and its impact on crime and commerce, privacy and data protection, and contemporary areas of Caribbean legal knowledge.

CAVE HILL CAMPUS – BARBADOS			
RELATED ACADEMIC PROGRAMME	**FACULTY**	**COURSE CODE**	**DESCRIPTION**
	Law	LAW 3760 Intellectual property law (Undergraduate)	Discusses intellectual property law within a wider commercial context and in light of emerging technologies that impact on how intellectual property rights are recognized.
	Science & Technology	COMP2410 – Computing in the Digital Age (Undergraduate)	Covers areas such as ethics, software engineering and software reliability, parallel computing, digital data and copyright, software as intellectual property, artificial intelligence, Big Data, crowd computing, wearable computing, etc.
		COMP3310 – Algorithms (Undergraduate)	Develops an understanding in the analysis of algorithms, time and space complexities, algorithm design techniques (brute-force, divide and conquer, pre-processing, dynamic programming, greedy algorithms), limits of computability (lower bounds, tractable and intractable problems, dealing with np-completeness) and empirical measurements of performance.
		COMP3450 – Fundamentals of Artificial Intelligence (Undergraduate)	Provides exposure to intelligent agents, search algorithms, knowledge representation, machine learning and probabilistic reasoning.
		ELET2235 – Automation Technology and Applications (Undergraduate)	Examines areas like microcontroller systems and architectures, Programmable Logic Controller (PLC) and Field Programmable Gate Arrays (FPGA) architectures and systems, industrial network topologies, Distributed Control Systems (DCS) and applications, and Supervisory Control and Data Acquisition (SCADA) systems and their applications.
		COMP3445 – Computer Information Systems (Undergraduate)	Includes a focus on societal and ethical issues relating to information systems, artificial intelligence, expert systems, and virtual reality, among other areas.
		COMP 6319 - Game Physics and Artificial Intelligence (Postgraduate)	Allows persons to create compelling, believable content for computer games, simulations, and animation with an emphasis on AI programming.
RESEARCH	**FACULTY**	**RESEARCH AREA**	**OVERVIEW**
	Science & Technology	Apart from the Faculty of Science & Technology, no other Faculties at the Cave Hill Campus appear to be engaged in AI-related research. However, the research papers and publications by the Faculty of Science and Technology at the Cave Hill Campus are currently not available on the Faculty's website, but Artificial Intelligence was highlighted as one of the research priority areas for this Faculty.	

UWI ST. AUGUSTINE CAMPUS – TRINIDAD & TOBAGO			
RELATED ACADEMIC PROGRAMME	**FACULTY**	**COURSE CODE**	**DESCRIPTION**
	Engineering	IENG 6009 - Robotic Technology & Automation (Postgraduate)	No available course description online.
		MENG 6203 -Robotic Technology & Applications (Postgraduate)	No available course description online.
		MENG 6504 - Technology and Product Development (Postgraduate)	No available course description online.
	Food & Agriculture	AGEX 3000 - Technology Transfer in Agriculture (Undergraduate)	No available course description online.
	Science & Technology	COMP 3610 - Big Data Analytics (Undergraduate)	Exposes students to the various approaches used in analysing big data. The course focuses on the use of data warehouses and distributed database design to analyse structured data and Hadoop for unstructured data. Students are also introduced to various NoSQL databases and approaches for storing and processing large volumes of data. The MapReduce model for processing large data sets in discussed and it is compared against the parallel database approach.
		INFO 2605 – Professional Ethics and Law (Undergraduate)	Provides an overview of current ethical standards and practices in the computing and information technology area. Students will develop an awareness of both the ethical and legal issues facing the computerized workplace.
		COMP 6401 - Advanced Algorithms (Postgraduate)	Focuses on performance evaluation of such algorithms, network flow algorithms, graph theory, network performance, capacity analysis, optimization algorithms and resource allocation. This course introduces students to the more sophisticated algorithms being developed for today's technologies.
RESEARCH	**FACULTY**	**RESEARCH AREA**	**OVERVIEW**
	Science & Technology	Artificial Intelligence Research	The AI related research in this faculty focuses on mainstreaming high-performance-computing for AI research and applications and the application of AI to the resolution of real world problems.

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UWI MONA CAMPUS - JAMAICA			
RELATED ACADEMIC PROGRAMME	**FACULTY**	**COURSE CODE**	**DESCRIPTION**
	Social Sciences	COMP5740 - Business Intelligence (Postgraduate)	Provides exposure to data mining techniques, building data warehouses, designing algorithms, etc.
		SBMA 6070 - Data Mining for Marketing and Sales (Postgraduate)	Emphasis in this course is placed on how to extract and apply business intelligence to improve business decision making and marketing strategies
	Humanities & Education	EDTK2025 - Introduction to Computer Technology in Education (Undergraduate)	No available course description online.
		EDTK3004 - Educational Technology (Undergraduate)	No available course description online.
		EDTK3025-Integrating Computers into the Curriculum (Undergraduate)	No available course description online.
	Law	LAW3765 - Law, Technology & the Internet (Undergraduate)	Examines the legal issues arising from emerging technologies. It focuses on aspects of the internet and its impact on crime and commerce, privacy and data protection, and contemporary areas of Caribbean legal knowledge.
	Science & Technology	COMP5210- Artificial Intelligence	Examines the different approaches to AI, the different views of AI, the applications of AI and the future of AI.
		COMP6210 - Advanced Artificial Intelligence (Postgraduate)	Provides an in-depth understanding of advanced AI concepts and gives practical experience in the construction of an AI application.
		COMP6430 - Topics in Advanced Algorithms (Postgraduate)	Covers advanced data structures and algorithms with emphasis on applications in which combinations of these basic structures are useful, other data structures that have good performance but often require a reasoning capacity to analyse them beyond what is normally expected at the undergraduate level and real-world applications that demand the performance yields of these advanced data structures.
		COMP6420- Parallel Computing (Postgraduate)	Aims to give students a knowledge of both hardware and software necessary for parallel computation. Topics include an introduction to basic concepts, parallel architectures, and network topologies, parallel algorithms, parallel metrics, parallel languages, granularity, applications, parallel programming design and debugging. Students will become familiar with various types of parallel architectures and programming environments.
		COMP3220 - Principles of Artificial Intelligence (Undergraduate)	No available course description online.

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UWI MONA CAMPUS - JAMAICA			
	FACULTY	**RESEARCH PAPER / PUBLICATION**	**OVERVIEW**
RESEARCH	Science & Technology	K.D.I.S - Knowledge Discovery and Intelligent Systems – This research group is headed by Dr. Gunjan Mansingh	KDIS's objective is to solve problems in domains where knowledge is embedded in humans as well as structured and unstructured data. They develop systems, methods, techniques, and algorithms in the sub-disciplines of AI (data mining, machine learning/deep learning), computational linguistics, big data, decision support systems, and knowledge management systems. The research projects in this group focus on various domains such as agriculture, healthcare, security, sports and has produced numerous publications.
		Complex Systems Modelling – This research group is led by Prof. Daniel N. Coore	Complex Systems Modelling group's areas of interest include spatial computing systems that adhere to the amorphous computing model and the development of supporting software simulation tools in addition to robotics and animation, especially in education applications. Many of this group's projects are interdisciplinary in nature and often overlap with areas in Science, Engineering and / Education.
		Parallel Computing – This research group is led by Dr. Simon Uzezi Ewedafe	Parallel Computing Group develops parallel algorithms on parallel virtual machines for scientific and engineering computation with cases for active thermal control processes and atmosphere processes. Their primary areas of interest are parallel numerical computation and mathematical computation.
		C.I.F.E.R (Computer Intrusions, Forensics and Exploitations Research) –This research group is led by Dr. Curtis Busby-Earle	C.I.F.E.R's areas of interest include multi-perspective machine learning, business readable formal software specification, loophole analysis and a standardized procedure for conceptualizing and completing user stories. This research group has produced numerous publications in these fields.

UWI FIVE ISLANDS CAMPUS- ANTIGUA & BARBUDA
Note: The Five Islands Campus was recently opened and there is little information about course offerings on the website. However, mention is made of a Bachelor of Science Degree with specialization in computer science and information technology – there are no details about the particular courses offered under these degrees – put perhaps AI-related content is included.

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