AI Landscape in Cambodia:
Current Status and Future Trends

MAY 2023

Ministry of Industry, Science, Technology & Innovation

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Phnom Penh, Cambodia

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Foreword

Artificial intelligence is ubiquitous in science, technology, and innovation development, especially in the current context of the Industrial Revolution 4.0. The foundation of science in inspiring natural behavior, together with an enormous amount of available data, is leveraging the potential of artificial intelligence to be more and more powerful in the context of management, planning, competition, and innovation. As a senior minister and minister of industry, science, technology, and innovation, I am delighted to value this important document entitled "Artificial Intelligence Landscape in Cambodia: Current Status and Future Trends," contributed by outstanding scholars. In my other capacity as Chairman of the National Council of Science, Technology, and Innovation, this document complements the respective mandates of science, technology, and innovation action in general and line ministries in particular. We all know that technology will be alongside us, especially in the development of the private sector, including industry, small and medium enterprises, and potable water. Harnessing technology in these sectors is very relevant in the current landscape of socioeconomic endeavor in the Kingdom of Cambodia. The contribution of the authors to this document is timely and triggers the readiness of STI actors to be more proactive and dynamic in this important evaluation of technologies.

Technical advancement, particularly artificial intelligence, is an undeniable fact that all of us should take for granted as changes for a better human civilization. In principle, the overarching role of science, technology, and innovation has remained with us for thousands of years. Technology development must be inclusive. However, we shall stay updated with the changes by harnessing critical technologies for social good. This reminds me of the priceless inheritance message—not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change—by Charles Robert Darwin, who is one of the greatest scientists of all time. On top of this quote from the father of evaluation, I am convinced that all of us, including government institutions, the private sector, and academia, shall be living with changes to survive, especially in the context of technological abruption. It is known that artificial intelligence is going to be with us more. However, feeding correct and sufficient data is our endless endeavor and critical from a technical point of view. On the other hand, I am also eager to take part in overseeing the development of technologies from a policy point of view.

"AI Landscape in Cambodia: Current Status and Future Trends" is the first scholarly document to grasp the state of the art and the future of this technology in Cambodia. I strongly encourage policymakers, the private sector, and academia to materialize this useful document for their respective missions. I am firmly convinced that the discussion provided in the report is a strong foundation for the development of your institution in particular and Cambodia in general.

Finally, I would like to thank the editors and contributors for this valuable material. This report marks the first step for the next generation to explore further expansion of knowledge and information about artificial intelligence for the betterment of Cambodia.

Phnom Penh, 29 May 2023

Senior Minister

Minister of Industry, Science, Technology & Innovation

Kitti Settha Pandita **CHAM Prasidh**

ខ្លឹមសារសង្ខេប

រយៈពេលជាងប្រាំមួយទសវត្សរ៍មកនេះ បញ្ញាសិប្បនិម្មិតមានការវិវត្តគួរឱ្យភ្ញាក់ផ្អើល និងត្រូវបានទទួល ស្គាល់ពីសមត្ថភាពរបស់វាតាមរយៈបណ្តាញណឺរ៉ូនសាមញ្ញធម្មតា (Simple Neural Networks) ការវិភាគអត្ថបទ ពហុកម្រិត (Multi-level Text Analytics) ការសិក្សាស៊ីជម្រៅ (Deep Learning) ការវិភាគរូបភាព (Image Analytics) របកគំហើញពីការសម្របខ្លួនដោយខ្លួនឯងនិងដំណើរការភាសាបែបធម្មជាតិក្នុងប្រព័ន្ធកុំព្យូទ័រ (Self-adaptive and Natural Language Processing Breakthrough) បច្ចេកវិទ្យាកុំព្យូទ័រគ្រាប់តាមប្រព័ន្ធប្រសាទ (Neuromorphic Technology) និងការចាប់ផ្ដើមនៃការអភិវឌ្ឍប្រព័ន្ធឆ្លើយតបនឹងមជ្ឈដ្ឋានជុំវិញត្រាប់តាមមនុស្ស (Human Consciousness System Development)។ បញ្ញាសិប្បនិម្មិតត្រូវបានយកមកអនុវត្ត និងចាប់យកមក ប្រើប្រាស់ក្នុងផ្នែកអាជីវកម្មសម្រាប់គោលបំណងជាច្រើនដូចជា ក្នុងកម្មន្តសាល ការវេជ្ជទាំសុខភាព ការលក់រាយទំនិញ ធនាគារ និងសេវាកម្មសាធារណៈ។ ការអភិវឌ្ឍយ៉ាងឆាប់រហ័សនៃបញ្ញាសិប្បនិម្មិត ទាមទារឱ្យមានចំណាត់ការលើ ដែនគន្លឹះមួយចំនួនក្នុងគោលនយោបាយ ឬច្បាប់ដែលអាចមាននៅថ្ងៃអនាគតក្នុងការគ្រប់គ្រងលើការប្រើប្រាស់ បញ្ញាសិប្បនិម្មិតដូចជា ឯកជនភាព គណនេយ្យភាព សុវត្ថិភាពនិងសន្តិសុខ តម្លាភាពនិងភាពអាចពន្យល់បកស្រាយ បានភាពមិនលម្អៀងនិងការមិនរើសអើង ការគ្រប់គ្រងរបស់មនុស្សលើបច្ចេកវិទ្យា ទំនួលខុសត្រូវវិជ្ជាជីវៈ និងការលើក តម្លៃមនុស្ស។ ក្រុមហ៊ុន និងអង្គការនានានៅគ្រប់វិស័យខិតខំបង្កើនសក្តានុពលនៃទិន្នន័យរបស់ពួកគេ ដើម្បីបង្កើត ការសម្រេចចិត្តដែលប្រសើរឡើងសម្រាប់គោលបំណងពាណិជ្ជកម្ម និងផលជះទៅលើសង្គម។ តាមទស្សនៈ បច្ចេកទេស មានទម្រង់មួយចំនួននៃកម្មវិធីបញ្ញាសិប្បនិម្មិតដូចជា ម៉ាស៊ីនស្វ័យសិក្សា (Machine Learning) ការសិក្សាស៊ីជម្រៅ (Deep Learning) ការសិក្សាបែបកូនកាត់ (Hybrid Learning) និងបច្ចេកវិទ្យាឌីជីថលភ្លោះ (Digital Twins)។

ឧស្សាហកម្មមួយចំនួនបាននឹងកំពុងទទួលអត្ថប្រយោជន៍ពីបញ្ញាសិប្បនិម្មិតនៅក្នុងប្រទេសកម្ពុជា មានដូចជា ការវេជ្ជទាំសុខភាព ការអប់រំ និងហិរញ្ញវត្ថុ។ សម្រាប់ការវេជ្ជទាំសុខភាព បញ្ញាសិប្បនិម្មិតអាចត្រូវបានប្រើដើម្បីបង្កើន សុក្រិតភាព និងប្រសិទ្ធផលនៃការធ្វើរោគវិនិច្ឆ័យ និងដើម្បីកំណត់ហានិភ័យសុខភាពដែលអាចកើតមាន រួមនឹង វិធានការបង្ការ។ ជាឧទាហរណ៍ បញ្ញាសិប្បនិម្មិតអាចវិភាគរូបភាពវេជ្ជសាស្ត្រ និងកំណត់អត្តសញ្ញាណនៃភាពមិន ប្រក្រតី ដូចជាដុំសាច់មហារីក ឬបញ្ហាសុខភាពដែលអាចកើតមានផ្សេងទៀត។ លើសពីនេះទៅទៀត បញ្ញាសិប្បនិម្មិត ត្រូវបានប្រើប្រាស់ក្នុងវិស័យអប់រំក្នុងប្រទេសកម្ពុជាដើម្បីលើកកម្ពស់គុណភាព និងលទ្ធភាពទទួលបានការអប់រំផងដែរ។

ផ្នែកមួយទៀតដែលបញ្ញាសិប្បនិម្មិតចាប់ផ្តើមមានផលជះខ្លាំងក្នុងប្រទេសកម្ពុជា គឺវិស័យហិរញ្ញវត្ថុ។ បញ្ញាសិប្បនិម្មិត ត្រូវបានប្រើប្រាស់ដើម្បីបង្កើនសុក្រឹតភាព និងប្រសិទ្ធផលនៃប្រតិបត្តិការហិរញ្ញវត្ថុ និងដើម្បីកំណត់អត្តសញ្ញាណ ការក្លែងបន្លំ និងការលោងលុយកខ្វក់ដែលអាចកើតមាន។ ជារួម ការអភិវឌ្ឍនិងការចាប់យកបញ្ញាសិប្បនិម្មិតនៅកម្ពុជា ស្ថិតក្នុងដំណាក់កាលដំបូងនៅឡើយ ប៉ុន្តែបច្ចេកវិទ្យានេះមានសក្តានុពលដើម្បីបរិវត្តទិដ្ឋភាពជាច្រើននៃសង្គម។ បញ្ហាប្រឈម និងកាលានុវត្តភាពចម្បងក្នុងវិស័យនេះ រួមមានតម្រូវការបំណេះដឹង និងជំនាញងកទេស ក៏ដូចជា តម្រូវការក្នុងការដោះស្រាយបញ្ហាក្រមសីលធម៌ និងឯកជនភាព។ ជាមួយនឹងនិរន្តរភាពនៃការវិនិយោគ និងការអភិវឌ្ឍ បញ្ញាសិប្បនិម្មិតមានសក្តានុពលខ្លាំងជាប្រយោជន៍ដល់ប្រទេសកម្ពុជាក្នុងពេលឆាប់ៗខាងមុខនេះ។ ជាយុទ្ធសាស្ត្រ ការស្រាវជ្រាវនិងអភិវឌ្ឍន៍ មានគុនាទីចាំបាច់ណាស់ដើម្បីឆ្លើយតបនឹងភាពឈានមុខនៅលើពិភពលោក។ ជាមួយ នឹងទឹកប្រាក់រាប់រយពាន់លានដុល្លារដែលរំពឹងថានឹងបង្កើតបានពីបញ្ញាសិប្បនិម្មិតនៅទូទាំងពិភពលោក កម្ពុជាឃើញពី តម្រូវការ និងភាពបន្ទាន់ដើម្បីរៀនិយោគ ចាប់យក និងរៀបចំខ្លួនដើម្បីឆ្លើយតបនឹងចរន្តជាសកលរបស់បច្ចេកវិទ្យានេះ ស្របតាមនិន្នាការឧស្សាហកម្ម ៤.០ ដែលសេដ្ឋកិច្ចផ្នែកសំខាន់លើចំណេះដឹង និងឌីជីថល។

មានបញ្ហាប្រឈម និងកង្វល់ជាច្រើនដែលកើតមានឡើងព្រមជាមួយការប្រើប្រាស់បញ្ញាសិប្បនិម្មិត។ ម៉ាស៊ីន ស្វ័យសិក្សាត្រូវការបរិមាណទិន្នន័យ និងពេលវេលាគណនាច្រើន។ ជាទូទៅ អ្នកស្រាវជ្រាវមានការប្រឈមក្នុង ការទទួលបានសំណុំវិធីបង្គាត់ដែលមានគុណភាពខ្ពស់ និងមិនលម្អៀង ដើម្បីបំប៉នបញ្ញាសិប្បនិម្មិត។ ក្នុងករណីជាច្រើន មានកំណត់ត្រារាប់សែនដើម្បីអនុវត្តក្បួនដោះស្រាយលើការសិក្សាស៊ីជម្រៅ (Deep Learning Algorithms) ឱ្យបាន សមស្រប។ សំណុំទិន្នន័យដែលផ្គុកព័ត៌មានលម្អៀង អាចនាំទៅរកលទ្ធផលដែលមិនចង់បាន។ ការប្រើប្រាស់ បច្ចេកវិទ្យានេះ អាចមានបញ្ហាប្រឈមជាវប្បធម៌ផ្សេងទៀតដែលគួរពិចារណា និងអាចបែកចេញជាបញ្ហាថ្មីៗផ្សេងទៀត សម្រាប់ការដើកនាំ។ ជាមួយគ្នានេះ មានការអត្ថបទជាច្រើនលើកឡើងអំពីបញ្ហាដែលបញ្ញាសិប្បនិម្មិត នឹងជំនួសម ការងារពីកម្មករដែលធ្វើការងារគ្មានជំនាញ ឬការងារស្វ័យប្រវត្តិដាយៗ។

នៅកម្ពុជា បច្ចេកវិទ្យានេះមិនមែនត្រឹមតែពាក់ព័ន្ធនឹងបញ្ញាសិប្បនិម្មិតប៉ុណ្ណោះទេ។ វាពាក់ព័ន្ធមិនត្រឹមតែការ បង្កើតក្របខណ្ឌឌីជីថលនៅក្នុងហេដ្ឋារចនាសម្ព័ន្ធដែលមានស្រាប់ប៉ុណ្ណោះទេ ថែមទាំងការពង្រឹងសមត្ថភាពសិក្សា លើបច្ចេកវិទ្យាកមនាគមន៍ និងព័ត៌មានផងដែរ។ ក្របខណ្ឌគតិយុត្តដែលពាក់ព័ន្ធលើទិន្នន័យ និងសន្តិសុខប្រព័ន្ធ អ៊ីនធើណិត ក៏ត្រូវការជាចាំបាច់ផងដែរដើម្បីប្រយុទ្ធប្រឆាំងនឹងឧក្រិដ្ឋកម្មតាមប្រព័ន្ធអ៊ីនធើណិត និងដើម្បីផ្តល់ការ ធានាដល់អាជីវកម្មពាក់ព័ន្ធ អ្នកអនុវត្ត និងអ្នកប្រើប្រាស់ក្នុងវិស័យនេះ។ កម្ពុជាក៏បានកសាងមូលដ្ឋានគ្រឹះបច្ចេកវិទ្យា

ដែលជាហេតុនាំរចនាសម្ព័ន្ធកន្លឹះជាច្រើនឆ្នាំដែលការណ៍នេះ នឹងត្រូវបានលើកកម្ពស់បន្ថែមទៀតដើម្បីបង្កើនផលជះ ជាអតិបរមានៃបញ្ញាសិប្បនិម្មិត។

ជាចុងក្រោយ បញ្ញាសិប្បនិម្មិតគឺជាបច្ចេកវិទ្យាដ៏សំខាន់មួយនៅក្នុងឧបាយផ្លាស់ប្ដូរ (Game changing) របស់ពិភពលោកនៅគ្រប់វិស័យ ដើម្បីបង្កើនផលិតភាព ប្រសិទ្ធផល និងប្រសិទ្ធភាពចំណាយ។ ដើម្បីជំរុញប្រព័ន្ធ អេកូឡូស៊ីបញ្ញាសិប្បនិម្មិតដែលអាចជឿទុកចិត្តបាន វាចាំបាច់សម្រាប់ប្រទេសនានាក្នុងការអភិវឌ្ឍគោលនយោបាយ ផ្អែកលើមនុស្ស ដែលលើកកម្ពស់ការស្រាវជ្រាវនិងអភិវឌ្ឍន៍បញ្ញាសិប្បនិម្មិតផ្អែកលើសង្គមសេដ្ឋកិច្ច និងប្រកបដោយ ការទទួលខុសត្រូវ ដែលរួមបញ្ចូលទាំងគោលនយោបាយដែលជំរុញឱ្យមានការវិនិយោគលើគំនិតផ្ដួចផ្ដើមក្នុងន័យ នេះផងដែរ។ គោលនយោបាយនៃការអភិវឌ្ឍបញ្ញាសិប្បនិម្មិតទាំងនេះ គួរតែគិតគូរផងដែរពីចក្ខុវិស័យអភិវឌ្ឍន៍ជាតិ ក៏ដូចជានិន្នាការតំបន់ និងសកល។ វត្ថុបំណង ទំនោរ និងយុទ្ធសាស្ត្រចម្បងរបស់ប្រទេសសម្រាប់ការរីកចម្រើន ផ្នែកបញ្ញាសិប្បនិម្មិតទាំងក្នុងពេលអនាគតគដ៏ខ្លី និងវែងឆ្ងាយ គួរត្រូវបានបញ្ជាក់ឱ្យច្បាស់លាស់។ ជាការចាប់ផ្ដើម វត្ថុបំណងចម្បងគឺដើម្បីបណ្ដុះបុគ្គលិកជំនាញ និងប្រើប្រាស់ដំណោះស្រាយបញ្ញាសិប្បនិម្មិត ដើម្បីដោះស្រាយ កិច្ចការដែលជាការផ្អែកសំខាន់របស់ជាតិ ដែលនឹងជះឥទ្ធិពលយ៉ាងឆាប់រហ័សដល់ស្ថានភាពសង្គមសេដ្ឋកិច្ចរបស់ ប្រទេសកម្ពុជា។ ក្នុងបរិការណ៍នេះ អាទិភាពគួរតែដាក់ទៅការអភិវឌ្ឍការស្រាវជ្រាវមូលដ្ឋាននិងកម្រិតខ្ពស់ ការលើក កម្ពស់ការស្រាវជ្រាវនិងនវានុវត្តន៍បញ្ញាសិប្បនិម្មិតកម្រិតខ្ពស់ និងការកសាងជំហររបស់កម្ពុជាក្នុងវិស័យបច្ចេកវិទ្យា ណានមុខរបស់សកលលោក។

Executive Summary

Over six decades, the evolutionary development of AI has been astonishing and proves its capability through simple neural networks, multi-level text analytics, deep learning, image analytics, self-adaptive and natural language processing breakthroughs, neuromorphic technology, and the edge of human consciousness system development. AI has been implemented and adopted in business sectors for a variety of purposes in manufacturing, health care, retail, banking, and public services. The rapid development of AI calls out key areas that need to be addressed in any future policy or law governing the use of AI, such as privacy, accountability, safety, and security; transparency and explainability; fairness and non-discrimination; human control of technology; professional responsibility; and promotion of human values. Firms and organizations across all sectors strive to maximize the potential of their data to make better decisions for commercial and social purposes. From a technical perspective, there are several types of AI applications, such as machine learning, deep learning, hybrid learning, and digital twins.

Some of the industries seen as benefiting from AI in Cambodia are healthcare, education, and finance. For healthcare, AI can be used to improve the accuracy and efficiency of medical diagnoses and identify potential health risks and preventative measures. For example, AI can analyze medical images and identify abnormalities such as tumors or other potential health issues. In addition, AI can be used in education in Cambodia to improve the quality and accessibility of education. Another area where AI is beginning to have an impact in Cambodia is finance. AI is being used to improve the accuracy and efficiency of financial transactions and identify potential fraud and money laundering. Overall, the development and adoption of AI in Cambodia is still in its early stages, but it has the potential to transform many aspects of society. The key challenges and opportunities in this area include the need for specialized skills and expertise, as well as the need to address ethical and privacy concerns. With continued investment and development, AI has the potential to greatly benefit Cambodia in the coming years. Strategically, R&D is essential to cope with the AI-enabled advancements in the world. With billions of dollars expected to be generated from AI globally, Cambodia sees the need and urgency to invest, adapt, and prepare for this AI global force in line with the industry 4.0 trend as the economy increasingly becomes knowledge- and digital-based.

There are many challenges and concerns that come with the use of AI. Certainly, machine learning requires massive amounts of data and computing time. Researchers are generally challenged when it comes to finding high-quality, unbiased training sets to teach AI. In many cases, hundreds of thousands, if not millions, of records, are required to properly implement deep learning algorithms. And data sets containing biased information can lead to undesirable results. There are other cultural challenges to consider that branch out into new issues for leadership.

when it comes to incorporating AI. Also, there has been much written about how AI will take jobs away from unskilled or easily automated workers.

In Cambodia, this technology is not just about AI. It is about creating a digital framework within the existing infrastructure to implement its learning capability alongside the work of information and communication technology. A relevant legal framework on data and cybersecurity is also needed to be in force to combat cybercrimes and provide assurance to relevant businesses, practitioners, and consumers in the field. Infrastructure is the key, and there is already a basic technological foundation that Cambodia has been building for years that will be leveraged to maximize the impact of AI.

Last but not least, AI is one of the essential technologies in the world that is game-changing in every sector to improve productivity, efficiency, and cost-effectiveness. In order to foster trustworthy AI ecosystems, it is essential for countries to develop human-centered policies that promote socio-economic and responsible AI research and development. This includes policies that encourage investment in such initiatives. These policies for AI development should take into account its national development vision as well as regional and global trends. The country's objectives, preferences, and overarching strategy for AI advancement in the immediate and distant future should be clarified. Initially, the main objective is to cultivate skilled personnel and employ AI solutions to deal with critical national focus areas that will have a swift impact on Cambodia's socio-economic status. Over time, the priority should shift to developing fundamental and advanced research, promoting high-level AI research and innovation, and establishing Cambodia's standing in advanced technology on a global.

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AI : Artificial Intelligence

AMS : ASEAN Member States

CDOs : Chief Data Officers

CPS : Cyber physical system

GDP : Growth Domestic Product

GDPR : General Data Protection Regulation

IoTs : Internet of Things

I4.0 : Industrial revolution 4.0

IPR : Intellectual Property Right

NLP : Natural Language Processing

OECD : Organisation for Economic Cooperation and Development

PPC : Production planning and control

R&D : Research and Development

SDGs : Sustainable Development Goals

SMEs : Small and medium-sized enterprises

STEM : Science, Technology, Engineering, and Mathematics

TVET : Technical and vocational education and Training

1. The Boundless Potential of AI: Adoption and regulations

1.1. Trend-Megatrends

The fast-moving trend of Artificial Intelligence (AI) has gained its impetus to fundamentally change the business and economy landscape and society for the last few years. The term Artificial Intelligence (AI) was first coined in 1956 to broadly address the machine simulation of intelligence where the machine can simulate every aspect of learning and feature of intelligence (Lau & Haugh, 2018). Over six decades, the evolutionary development of AI is astonishing and proofs its capability from simple neural networks, multi-level text analytics, deep learning, image analytics, self-adaptive and natural language processing breakthrough, neuromorphic technology, and the edge of human consciousness system development. At this new stage of AI commercialisation, the ecosystem of industries is disrupted and expectedly forcibly transformed into digital and technological capability at various layers (Deloitte, 2019); firstly, the enterprise with maturity in AI application and capable resources will use AI in both management and production processes to foresee, with the use of data-mining, the global megatrend and the ability of their products and services to be commercialised. This enterprise change will cover sales, security, anti-fraud, human resource management, marketing, personal assistant, and smart tools. The second layer of industry change is expected to optimise the relationship between upstream and downstream sectors on the traditional industry chain where the consumer can access the product features directly. This industry change will take its course in finance, healthcare, education, retail, manufacturing, media, agriculture, and logistics, to name a few. Lastly, the future labor structure of enterprises will be transformed with virtual and augmented realities, gesture recognition, and robots to increase productivity and competitiveness.

The embrace of AI among ASEAN member states (AMS), of which 83% of ASEAN is at the early stages, and 15% of ASEAN is at advanced stages, is still at the nascent stages given the differences in the national priority, strategic investment, piloting initiatives within discrete activities, scaling initiatives, and end-to-end scaled implementation of AI (Chua and Dobberstein, 2020). The potential of AI contribution to the region's Growth Domestic Product (GDP) is forecasted to be approximately US\$ 1 trillion, accounted for about 10 to 18% of DGP uplift across AMS in 2030. Nevertheless, the impact variance will be varied from one AMS to another based on the country's maturity in terms of AI infrastructure and adoption readiness; for instance, Cambodia, at the early stage of AI adoption, focuses more on the primary sectors (Chua and Dobberstein, 2020). The top five sectors which will benefit from AI include (1) manufacturing, (2) retail and hospitality, (3) agriculture, (4) government, safety/security, and smart cities, (5) healthcare. With Industry 4.0 technologies, AI could further advance the entire value chain, from product engineering and supply chain management to logistics and circular management. While having a dynamic and

mobile-centric population, the ASEAN region will boost retail and hospitality with machine learning and big data advancement. For the agricultural sector, drone and image recognition technologies will contribute to the prevention of crop diseases, pesticide and fertiliser application, and post-harvest management. Amid the complexity of challenges pertaining to the public sectors, AI will play an essential role in resources' optimisation, traffic congestion relief, education, and healthcare such as the accessibility to healthcare service, tracking, and management of infectious diseases.

AI is no longer the futuristic term in Cambodia as the AI community is exponentially growing while AI technologies have become a reality and used in various sectors. Early AI community is seen in http://cambodia.ai/, i.e., an open-source algorithms community to develop AI skills in Cambodia, initiated by a regional start-up, www.slash.co. One such AI application is the flood detection system, managed by People In Need, to potentially identify "false positive" alarms and predict flood risk among other projects: identity match, fraud detection, smart city, Khmer Chatbot, eKYC[Know Your Customer] system, and AI for Real Estate business. Another deployment of AI is the Demine Robotics with the three key functions: (1) detect, (2) retrieve, and (3) destroy and the uniqueness of this robot is its small size, strength, intelligence, machine efficiency, machine sensitivity, and data collection. Other AI prototypes include SCARA Robot, 4DOF Robot Manipulator, Dual Axis Solar Tracker, Drone (Hexacopter), and Mobile Robot using Omni Wheel, at Intelligent Mechatronics Laboratory, Institute of Technology of Cambodia. Universities including the National Institute of Posts, Telecommunications and ICT with new name as Cambodia Academy of Digital Technology, the American University of Phnom Penh, Kirirom Institute of Technology, and the Institute of Technology of Cambodia offer courses in AI, which will nurture the local talent. While constrained by the lockdown and health-safety measures, the early transformation of the soft and hard infrastructure of business could be seen across Cambodia. The earliest is the dine-in restaurant, where the service is turned to only takeaway and delivery. The drive-through and curbside restaurant and stores become reliant on the pre-order and delivery App. The school is closed, and the physical classroom becomes online. Digital platforms and services viz Foodpanda, Nham24, BLOC, Cambodia AEON Online, become overnight popular. As such, AI integration will be potential for business in Cambodia.

1.2. Need – AI adoption

Artificial Intelligence has the capability to simulate intelligent, human-like behavior in computers, high speed with cutting-age technology, where the applications of AI are enormous including finance, healthcare, cybersecurity, education, agriculture, transportation, law, etc. There are various forms of AI, such as Machine learning, Expert Systems, Robotics, Neural Networks, Fuzzy Logic, and Natural Language Processing. For instance, machine learning in which machines could encompass neural networks and deep learning, like our human brains, can observe, analyse, and

learn from facts and errors rather than being told what to believe. This technology has an impact on consumer items and has resulted in important discoveries in healthcare and physics, as well as changes in industries as diverse as manufacturing, banking, and retail. Over time, machine learning algorithms increase their performance by learning from data. In this way, computers can adapt to conditions that are unforeseen and cannot be codified by static rules. Driving a car and chatting with a customer are examples of such jobs. On rare occasions, the computer may even come up with a solution that no human has ever thought of (Marr, 2021; Smart Nation Digital Government Office, 2019).

For instance, AI has been implemented and adopted in industry for a variety of purposes, including (Marr, 2021; SAS Institute Inc., 2023):

- Manufacturing: AI can be used to optimise key areas of production such as yield, energy or throughput optimisation, assembly, and quality testing during the manufacturing process
- Heath Care: A personal health care assistant will be able to help with daily tasks (medicine, exercise, diet, detect the patient illness symptom) and to predict chronic disease
- Retail: Consumers may do virtual shopping, receive tailored suggestions, and discuss their purchasing alternatives. With the help of AI, the business will grow faster
- Banking: AI improves speed, precision, effectiveness of human error with ability to detect the fraudulent of unusual transactions, etc
- Public Sector: Make smart cities smarter, support the national defense, enhance effectiveness of the public services, etc.

The application of AI is limitless. It will always depend on its purpose, ie., who and where should AI be adopted, must be carefully determined.

1.3. Alignment to Vision

Artificial intelligence's progress and spread provide new and significant problems for technologists, humanity, and sentient life in general. The question of what—or whose—values AI systems should be associated with is the most important of these (Gabriel, 2020) . Furthermore, there is a lack of clarity and consistency in the worldwide debates about AI that are taking place among governments and the private sector on what the guiding principles should be for policymakers, academics, and companies. There is widespread agreement that legislative guidelines and safeguards are needed for the use of AI/ML (Artificial Intelligence/Machine Learning) in healthcare; but, before effective legislation can be developed, there must be consensus on the technology's vision and goal.

Regulation is built on the foundation of pre-existing ideas and beliefs about what technology is, what it seeks to achieve, and how it should be utilised. This involves (1) Determining how it will not be utilised and (2) assessing the risks that should be avoided. Organisation for Economic Cooperation and Development (OECD) AI principles identify as the following (OECD, 2023):

- AI should benefit people and the planet by driving inclusive growth, sustainable development, and well-being
- AI systems should be designed in a way that respects the rules of law, human rights, democratic values, and diversity, and they should include appropriate safeguards — for example, enabling human intervention where necessary — to ensure a fair and just society
- There should be transparency and responsible disclosure around AI systems to ensure that people understand AI-based outcomes and can challenge them
- AI systems must function in a robust, secure and safe way throughout their life cycles, and potential risks should be continually assessed and managed
- Organisations and individuals developing, deploying or operating AI systems should be held accountable for their proper functioning in line with the above principles.

The OECD also provides specific recommendations to governments on how to put these value-based principles into action:

- Facilitate public and private investment in research & development to spur innovation in trustworthy AI
- Foster accessible AI ecosystems with digital infrastructure and technologies and mechanisms to share data and knowledge
- Ensure a policy environment that will open the way to deployment of trustworthy AI systems
- Empower people with the skills for AI and support workers for a fair transition
- Co-operate across borders and sectors to progress on responsible stewardship of trustworthy AI.

The application of the OECD principles is still questioning since many organisations have their own principles of AI usage as well. These themes call out key areas that need to be addressed in any future policy or law governing the use of AI such as privacy, accountability, safety and security, transparency and explainability, fairness and non-discrimination, human control of technology, professional responsibility, and promotion of human values. To fit with Cambodia's vision of the future for utilisation of AI, strategic adaptation of AI usage, the concepts from the OECD and other major organisations should be examined in order to develop country rule,

legislation, regulation, and guidelines on how AI should be utilised for government, private, and corporate purposes.

2. AI-powered business and industry: Transforming Business Landscape in Cambodia

2.1. Business

Artificial intelligence has the potential to revolutionise many aspects of business, from improving decision-making and automation to enabling new products and services. In recent years, AI has become increasingly widespread in business, with many organisations adopting AI technologies to gain a competitive edge. However, Cambodian businesses are yet to take a full advantage of AI solutions. One of the key ways that AI is being used in business is for decision-making and automation. AI algorithms are able to process vast amounts of data and identify patterns and trends that can inform business decisions. This allows organisations to make more accurate and efficient decisions, which can lead to improved operations and increased profitability.

In addition, AI is being used to automate many tasks and processes in business. For example, AI algorithms can be used to automate customer service, data entry, and other routine tasks, freeing up employees to focus on more complex and value-added activities. This can help to increase productivity and reduce costs. In Cambodia, simple machine AI for use in industrial factories is being developed by Quantum Engineering and Manufacturing.

Another area where AI is having a significant impact on business is in the development of new products and services. AI algorithms are being used to create personalised experiences for customers, such as personalised product recommendations and personalised content. This can help to improve customer satisfaction and fidelity, and can also drive revenue growth. However, the use of AI in business is not without its challenges. One of the key issues is the need for specialised skills and expertise. Developing and deploying AI algorithms requires a high level of technical knowledge, and many organisations may struggle to find the necessary talent. In addition, there are often ethical and privacy concerns surrounding the use of AI in business, and organisations need to carefully consider these issues.

Some of the industries that can benefit from AI in Cambodia are healthcare, education, and finance. For healthcare, AI can be used to improve the accuracy and efficiency of medical diagnoses, and to identify potential health risks and preventative measures. For example, AI can analyse medical images and identify abnormalities, such as tumors or other potential health issues. This can help to improve the quality of healthcare and reduce the risk of misdiagnosis. There are currently already developed equipment and tools that Cambodian healthcare centers can acquire and implement.

In addition, AI can be used in education in Cambodia to improve the quality of and accessibility to education. For example, AI can be used to create personalised learning experiences for students, allowing them to learn at their own pace and in a way that is tailored to their individual needs. This can help to improve student outcomes and increase the efficiency of the education system.

Another area where AI is beginning to have an impact in Cambodia is in finance. AI is being used to improve the accuracy and efficiency of financial transactions, and to identify potential fraud and money laundering. This can help improve the security and reliability of the financial system, and can also help increase the access to financial services for individuals and businesses.

AI is transforming many aspects of business, and its impact is likely to continue to grow in the coming years. Organisations that are able to effectively adopt and integrate AI technologies are likely to gain a competitive advantage, while those that are unable to do so may struggle to keep pace in the competition.

Overall, the development and adoption of AI in Cambodia is still in its early stages, but it has the potential to transform many aspects of society. The key challenges and opportunities in this area include the need for specialised skills and expertise, as well the need to address ethical and privacy concerns. With continued investment and development, AI has the potential to greatly benefit Cambodia in the coming years.

2.2. Infrastructure

Artificial intelligence is a rapidly growing field that has the potential to transform many aspects of society, from healthcare and transportation to finance and education. However, for AI to reach its full potential, it requires a robust infrastructure that can support the development and deployment of AI systems. Currently in Cambodia, there is no proper AI infrastructure that allows complex development in the field. In this report, we will explore the current state of AI infrastructure and discuss some of the key challenges and opportunities in this area generally and in Cambodia (Sallomi et al., 2018). AI infrastructure refers to the hardware, software, and other resources that are needed to support the development and deployment of AI systems (Muller, 2022). It includes the hardware and software platforms, data storage and management systems, and other tools and resources that are required to build, train, and deploy AI models.

One of the key components of AI infrastructure is the hardware on which AI algorithms are run. In recent years, there has been a significant increase in the availability of specialised hardware for AI, such as graphical processing units and tensor processing units. These hardware platforms are designed to be highly efficient at running the complex calculations required by many AI algorithms, allowing them to perform faster and more accurately. However, the development of

specialised hardware for AI is not without its challenges. One of the key issues is the cost of these platforms, which can be prohibitively expensive for many organisations. In addition, the rapid pace of innovation in the AI hardware space means that the hardware used for AI today may quickly become outdated.

Another important component of AI infrastructure is the availability of data. AI algorithms require large amounts of high-quality data to be trained and tested. The availability of data is therefore a key factor in the development of AI systems. However, the collection and curation of high-quality data can be a time-consuming and expensive process. In addition, there are often privacy and ethical concerns surrounding the use of data for AI purposes. One potential solution to these challenges is the use of synthetic data, which is data that is generated artificially rather than collected from real-world sources. Synthetic data has the advantage of being readily available and controllable, but it can be difficult to ensure that it accurately reflects the real-world conditions that AI systems will encounter (Dilmegani, 2022).

In addition to hardware and data, AI infrastructure also includes the software tools and platforms that are used to develop and deploy AI systems. There are a wide variety of tools and platforms available, ranging from open-source libraries and frameworks to proprietary software tools. This includes programming languages such as Python, and libraries such as TensorFlow, and PyTorch, as well as tools for data preprocessing, model training, and model deployment. These tools and platforms can make it easier for developers to build and deploy AI systems, but they can also introduce their own challenges, such as vendor lock-in and the need for specialised skills.

Other parts of AI infrastructure include the data storage and management systems to store and organise the large datasets that are used to train and test AI models. This may include data warehouses, databases, and other storage systems that are designed to handle the scale and complexity of AI data.

Overall, the development of AI infrastructure is a complex and rapidly evolving field. For a country like Cambodia to participate in this development, it requires a combination of specialised hardware, high-quality data, and powerful software tools and platforms. The challenges and opportunities in this area are numerous, but with continued investment and innovation, AI has the potential to transform many aspects of society in the coming years. Thus, a robust plan for AI investment and implementation might be a worthwhile challenge for Cambodia.

Artificial intelligence (AI) has the potential to revolutionize many aspects of business, from improving decision-making and automation to enabling new products and services. Moreover, Cambodian businesses are yet to take full advantage of AI solutions.

One keyway AI is used in the business is for decision-making and automation. Hence, AI algorithms can process vast amounts of data and identify patterns and trends that can inform business decisions, allowing organizations to make more accurate and efficient decisions, leading to improved operations and increased profitability.

In addition, AI is being used to automate many tasks and processes in business. For example, AI algorithms can automate customer service, data entry, and other routine tasks, freeing employees to focus on more complex and value-added activities (Scheneider, 2017). This can help to increase productivity and reduce costs. For example, in Cambodia, simple machine AI for use in industrial factories is being developed by Quantum Engineering and Manufacturing.

Another area where AI is having a significant impact on business is in the development of new products and services. For example, AI algorithms create personalized customer experiences, such as product recommendations and content, that can help improve customer satisfaction and loyalty and drive revenue growth. However, the use of AI in business has its challenges. One of the key issues is the need for specialized skills and expertise. Developing and deploying AI algorithms requires a high level of technical knowledge, and many organizations may need help finding the necessary talent. In addition, there are often ethical and privacy concerns surrounding the use of AI in business, and organizations must carefully consider these issues. For example, there are already developed equipment and tools that Cambodian healthcare centres can acquire and implement. In addition, AI can be used in education in Cambodia to improve the quality and accessibility of education. For example, AI algorithms can be used to create personalized learning experiences for students, allowing them to learn at their own pace and in a way tailored to their individual needs, which can improve student outcomes and increase the efficiency of the education system.

Another area where AI is beginning to have an impact in Cambodia is finance. AI algorithms are being used to improve financial transactions' accuracy and efficiency and identify potential fraud and money laundering. This can improve the security and reliability of the financial system and help increase access to financial services for individuals and businesses. AI is transforming many aspects of business, and its impact will continue to grow in the coming years. As a result, organizations that can effectively adopt and integrate AI technologies will likely gain a competitive advantage. At the same time, those unable to do so may need help to keep pace with the competition.

Overall, the development and adoption of AI in Cambodia are still in their early stages, but it can potentially transform many aspects of society. The key challenges and opportunities in this area include the need for specialized skills and expertise and the need to address ethical and privacy concerns. Nevertheless, with continued investment and development, AI has the potential to benefit Cambodia in the coming years greatly.

3.   AI Revolution: Global Trends and Practical Applications

In today's data-driven world, the application of AI around the world continues to grow exponentially. Firms and organisations across all sectors strive to maximise the potential of their data, to make improved decisions for commercial purposes and social impact. From a technical perspective, there exists several forms of AI applications such as Machine Learning, Deep Learning, Hybrid Learning, and Digital Twins. According to pricewaterhousecoopers (2023), Machine Learning can be utilised for 3D mapping of bridge construction – based on data from drones, as well as for spotting insider trading. In addition, Deep Learning is being used to develop customer behavior models. Furthermore, Hybrid Learning that is based on probabilistic programming in using incomplete information to work with uncertainty, can be beneficial for analysing market behavior and regulatory environments. Finally, Digital Twins that replicate virtually physical and non-physical assets, are ideal for capital project management and helping financial institutions to model individual policyholders, as well as simulate future balance sheets and cash flows.

Moving onto more practical use cases of AI, Massachusetts Institute of Technology Sloan "6 Trends in Data and AI for 2021 and Beyond" mentions that: "1) Companies continue bold momentum, 2) Customer experience analytics take center stage, 3) Those who leverage external data outperform competitors by double digits, 4) Chief Data Officers lead the charge toward a data-driven culture, 5) Data science loses its luster, and 6) Data exposes wide gaps in equity – and also empowers change". Trend 1) Companies continue bold momentum – focuses on the continuous growth of AI applications during the COVID-19 pandemic, including the acceleration of cloud migration plans, taking advantage of this disruptive period to challenge the status quo and undergo digital transformation, as well as focusing on the first 1% of change – which is often the most challenging step. Trend 2) Customer experience analytics take center stage – highlights the importance of customer-related data to improve customer experience with the help of data fabric and data lakehouse, and analysing different forms of interactions such as voice analytics and customer interaction with chatbots or call centers. Trend 3) Those who leverage external data outperform competitors by double digits – emphasises starting with the core business problem, followed by strategising what potential data could be utilised to solve it, in addition to modernising data flows. Cindi Howson, Chief Data Strategy Officer of Thoughtspot, shared that "The range of data sources has exploded, the only thing lacking here is really your imagination." Trend 4) Chief Data Officers (CDOs) lead the charge toward a data-driven culture – shines a light on the growing significance of CDO roles, in showing companies and employees the efficiency gained with using data, consequently requiring the upskill of workers to take full advantage of new technologies. Trend 5) Data science loses its luster – discusses the importance of rebalancing the overemphasis on coding and math, but rather focusing on business application and improving communications skills and data storytelling. Trend 6) Data exposes wide gaps in equity and

empowers change – narrows down on the biased data and lack of team diversity building AI programs, which in turn, skews the output of AI algorithms. In conclusion, the article conveys that AI applications should strive for a "smarter, more fact-driven world, powered by data and analytics" (Brown, 2021).

The COVID-19 pandemic has also led to the establishment of a wide range of AI applications, in efforts to tackle its resulting challenges. Forbes "The 4 Top Artificial Intelligence Trends for 2021" describes several use cases of AI, starting with smarter big data analytics and insights. Big Data and AI applications are being utilised to quickly analyse and interpret data on the spread of the virus around the world, including a Natural Language Processing (NLP) powered search engine to navigate COVID-19 related literature in data sets, as well as Machine Learning to identify outbreaks with more ease, contact tracing between infected individuals, enabling more accurate diagnoses, predicting virus evolution, and developing more effective lasting vaccinations. In addition, automated detection and prevention is being carried out in the form of drones to detect COVID-19 symptoms such as high temperature of individuals in crowds, in combination with computer vision to analyse camera data. Businesses are also utilising data to rebound from the commercial and economic impacts of the pandemic, by predicting behavioral transformation. Finally, collaborative AI initiatives are being prepared around the world, to shut down the next pandemic before it even starts. Learning from the past pandemics and the current COVID-19 pandemic, the international exchange of relevant data and best practices will play a major role in preparing for the future (Marr, 2020).

4. Driving AI Development in Cambodia: The Power of Collaboration

Generic introduction of the chapter; why is collaboration important? Where to start? How to start? What are the challenges for local and global collaboration? What will be the impact of success and failure on building collaboration?

Collaboration plays a pivotal role in knowledge sharing, particularly important for multi-disciplinary/multi-country research, innovation and development work. In many occasions, knowledge sharing occurs through reported articles that are not security-sensitive, do not have Intellectual Property Right (IPR) issues and are not sensitive to financial income. Globally, many countries developed strategic agreements to share their knowledge related to security (for example, the UK with the US), business and socio-economic growth. Data collection, analysis and decision making using AI are playing a significant role in this type of knowledge sharing framework. The knowledge sharing framework brings various benefits, for example, this saves a significant research or innovation investment for the reinvention of the wheel. The Cambodian government and businesses should take initiative to develop similar regional and global collaboration based on the needs of the socio-economic growth and security of the country. This requires developing a strategic framework for specific data or knowledge to be shared for the

important sectors: security, innovation and research, crisis and disaster management, cultural understanding, economic growth, health and well-being. Failure to build this type of strategic collaborative knowledge sharing activity will bring detrimental effects on the sustainable development Goals (SDGs) (Sustainable Development Solution Network, 2023) and security (particularly, cybersecurity) of the country. However, the key challenges in building collaboration are normally the trust of the stakeholders, barriers for mutual economic benefits and communication/cultural gaps between the parties. To overcome these challenges, the stakeholders need to communicate and discuss developing a strategic long-term regional and global collaboration framework using data and knowledge sharing infrastructure.

4.1. Quadruple/ Triple Helix Approach

Why are the stakeholders' engagement/collaborations important, particularly for a country like Cambodia? Who will take initiative? How? When? How to prepare a sustainable collaborative framework? What are the key factors that may stimulate applied research and innovation to build collaboration? Should we start with Quadruple/triple/both helix approaches?
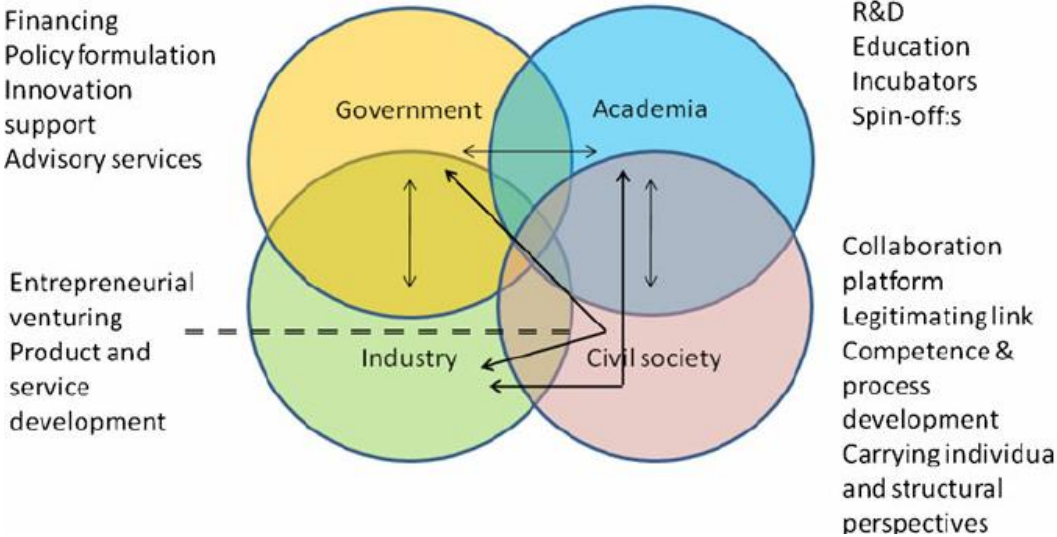
Figure 1. Collaborative Quadruple Helix Framework (Lindberg et al., 2014)

The stakeholders' engagement/collaborations are important particularly in a country like Cambodia because we need to enhance the development of new knowledge and to transform this knowledge into innovations. Cambodia's development challenges include manufacturing, agriculture, healthcare, transportation, energy, science and technology. The initiative needs to come from the local government as it plays an important role in integrating changes in principles and practices into local development and investment plans.

Working together to establish relationships toward a process to generate the outcome of something in common are essential characteristics that may inspire applied research and innovation to foster collaboration. Because addressing issues requires more than one person,

group, or organisation, collaborative connections are critical; hence, the outcome of collaboration might generate new metrics of success in economic development.

A collaborative approach includes more than just working together. It refers to the ability to work together and take action on large-scale projects. Traditional strategic planning is not a good model for the disciplines that will be required to rebuild our economy. Thinking together refers to a series of interactions involving academics (the university), business, and government in order to encourage economic and social growth through a Triple Helix model of innovation.

Several nations have embraced the Triple Helix approach to foster innovation through the notion of institutions and policy making. The Triple Helix interaction pattern is said to be capable of establishing links and interactions between science and technology, as well as gathering individuals from many disciplines to engage in the process of information exchange, ideas, and thoughts.

The quadruple helix paradigm may be regarded as an improvement on the triple helix approach in that it not only focuses on the players from academics, government, and business but also acknowledges society's growing involvement. The framework seeks to bridge the gap between innovation and civil society, claiming that under the triple helix paradigm, new technologies do not necessarily meet societal expectations and requirements, limiting their potential effect.

Investing more in research, innovation, and entrepreneurship should be at the core of Cambodia's development strategy, since it is the only way to achieve smart, sustainable, and inclusive growth. This idea expands on the triple helix model by assuming that society, in addition to academics, business, and government, is a significant actor in innovation processes.

Cambodia may be ideal for creating smart specialisation plans based on the quadruple helix method, which would create an environment conducive to entrepreneurship and innovation, which has been identified as a priority by policymakers and politicians. This is primarily because innovation and entrepreneurship are viewed as means to create new employment while also raising living standards through new and improved products.

However, in order for the quadruple helix method to work we need a good leader who can turn knowledge into action. A good Leader needs to be good with the group and be able to manage the multidisciplinary/multi-countries collaborative teamwork. How can we effectively support individuals while simultaneously changing big systems? By follow some of these rules:

- One conversion at the time, stay focused as design thinking offers an approach for addressing these and other big questions
- Restraint from criticising an idea
- Work with cool ideas and buildable

- Work on a time constraint, if not the team will never get anything done
- Mock up combine into a working prototype
- Fail often in order to succeed sooner
- Took the best element out of every prototype and created another workable.

A Lot of hours, be open minded, a leader that is demanding fresh ideas, be quirky and clash with him. A belief that Chaos can be constructive and teamwork a great deal of teamwork, and these a good recipe for innovation. The team needs to explore the paradox of cross-boundary work and learn about trust dynamics, conflict management, and the advantages and challenges of global teams.

4.2. Common and Inclusive Development

What are the common issues that may stimulate mutual benefits and opportunities of collaboration? What are the key challenges (including the digital divide) for inclusive development? How could we develop a collaborative framework that will help in inclusive development? Which stakeholders should contribute to addressing the inclusive issue and in what form – a table might help? Biasness, inequality and ethical issues related to inclusive development.

The common issues that may stimulate mutual benefits and opportunities of collaboration are manufacturing, agriculture, healthcare, transportation, energy, science and technology. The key challenges including the digital divide for inclusive development are:

- **Skill gap in AI at all educational levels**

This involves revisions at the elementary, secondary, and tertiary levels of education to include AI-related courses and programs into school curriculum. It is also necessary to provide chances for instructors to receive training and upskill in order to teach AI-related courses. Second, numerous policies give specific incentives for large-scale lifelong learning and reskilling via massive open online courses and reskilling.

- **Gender inequality in science and technology fields**

Skill shortages are a major impediment to innovation, stifling productivity growth and economic progress. Shortages of skilled professionals in areas linked to Science, Technology, Engineering, and Mathematics (STEM) in particular may limit a society's ability to innovate. Over the years, a significant gender disparity has remained at all levels of STEM disciplines around the world. Throughout the world, a significant gender disparity has remained at all levels of STEM fields. Despite significant gains in women's involvement in higher education, they remain underrepresented in these professions. This issue is particularly serious at the top of academic and professional hierarchies. Empirical studies show that countries with a higher proportion of

engineering graduates tend to grow faster than countries with a higher proportion of graduates in other disciplines

- **Lack of AI policy related to smart governance, smart innovation and smart regulations**

The absence of information in Cambodia refrains academics from furthering their understanding of the problem and policymakers from devising effective remedies. This note intends to add to the regional academic and policy discussion by examining the key variables proposed in the literature to explain gender discrepancies in STEM recruitment, retention, and promotion, as well as by proposing new factors.

- **Ethical, Privacy and IPR issues**

The ethical issues of AI applications are growing significantly. This includes data privacy and IPR associated with the data. Therefore, a strategic plan is essential to avoid misusing AI growth and data associated with that.

4.3. Global Education, Research and Innovation

- Why is the global collaboration for knowledge sharing through education, research and innovation important?
- What are types of collaboration to be developed? With which organisations/countries? How to build these collaborations? What are the funding agencies that may help in stimulating this collaboration?
- How to develop trained/skilled manpower to build collaboration – hire initially?
- When to start and where to start? Research-informed teaching to accelerate the process
- National AI and Data Centre for Research and Development (R&D)
- Commercialisation of the outcomes of AI research & innovation.

Research, innovation, research-informed teaching and AI application development to solve real-world problems are interconnected as shown in Figure 2. It reflects multidisciplinary collaborative teamwork is always key to achieve success. AI application is a market-driven dynamic area, therefore, requires global collaboration and rapid policy actions to play with the international partners. This also requires continuously identifying skill gaps in education, research and innovation. Based on the gap, there should be a method to train young talent abroad to fill this gap. Subsequently, offer an attractive incentive to the trained talent to return to the existing workforce at home. To create this opportunity, Cambodia needs to develop a strategic collaboration with regional and global institutions, offer scholarship based higher study for

talented young people and make an attractive support framework with a national AI and data centre as their home.

A strategic plan for R&D is very important to cope with the AI-enabled advancement in the world. The plan should have objectives and a direction of advancements to amplify efficiency. Cambodia sees itself thriving significantly in creating world-class research and advancement in some innovation fields. It is obligatory that AI is embedded in the R&D as well as other divisions to leverage its potential application. Based on our investigation, we recommend the following in the strategic plan:

- Need to set up a centre of excellence with leading experts from different backgrounds to work together for AI, data and associated technologies
- A collaborative framework (see Figure 2) with industries, universities, government and young entrepreneurs for applied research and innovation for knowledge transfer
- Regular engagement for knowledge sharing through meetings, seminars and interactive workshops
- Government investment strategy with an appropriate policy framework to promote the job skills of the young people
- Development of research centres in the universities in collaboration with industries and business to promote research/innovation informed teaching
- Develop a database of experts in Cambodia to promote collaborative activities with government support
- Develop a policy and practices for security, privacy and ethical issues related to the data and AI applications
- Need continuous exploration for potential regional and global research and innovation funds, staff/student exchange opportunities and partnership development to exchange knowledge
- Last but not least, develop a strategic framework to attract young people for new skill sets through a public-private partnership

Finally, Cambodia is moving towards a digital economy with new challenges as a middle-income country in 2030. A collaborative framework as shown in Figure 2 with strategic investment and policy is essential to develop skill sets of young people for AI applications. As applied research is key to generating knowledge, we need to embed this into the teaching, training and innovation for dynamic technology changes with a focus on sustainable economic growth.
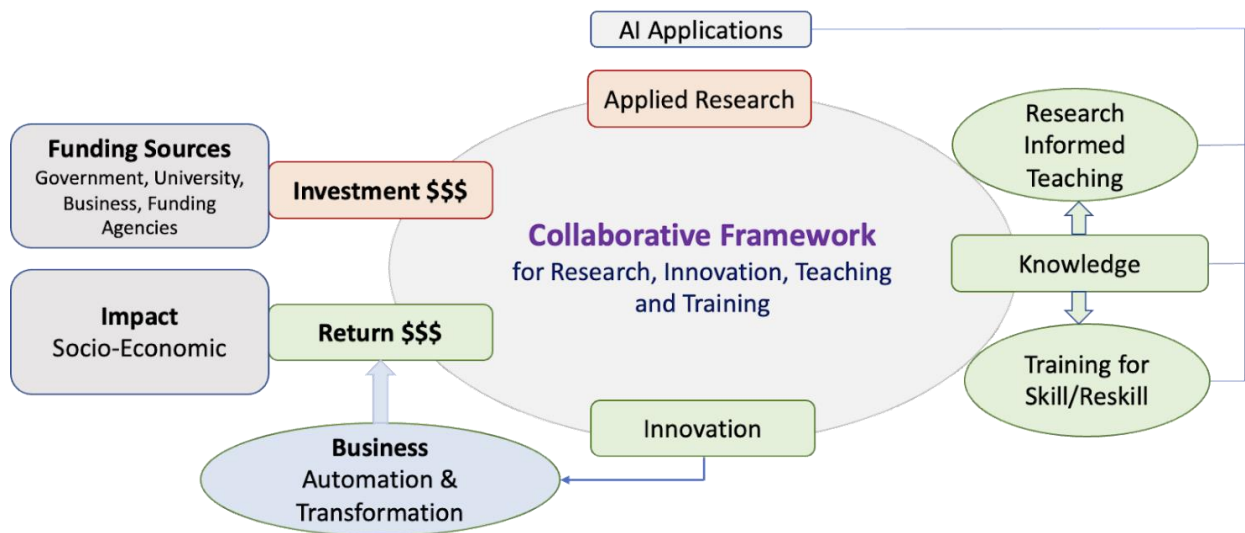
Figure 2. A collaborative framework to work together to develop new skill sets, research, research informed teaching and innovation.

5. AI for Socio-economic Transformation: A Strategic Vision and Roadmap

5.1. Socio-economic Impact

Accenture research on 12 developed economies countries indicated that AI has the power to double annual economic growth rates in 2035, changing the nature of work and creating a new relationship between man and machine. Also, the world economic forum reported that AI and Robots would create more jobs than they displace. Because of AI and related technologies, economic growth will boost up than ever before and create many additional job opportunities. According to McKinsey Global Institute, about 160 cases of SDGs where AI can be instrumental in solving problems.

It has been suggested that AI can help a country such as Cambodia achieve approximately 80 percent of all the development targets listed in SDGs by 2030 largely through the improvement of technology itself which is the main component in economic growth theory (Vinuesa et al., 2020). In particular, AI can, for instance, help increase productivity and income and thereby significantly decrease absolute poverty or identify areas with a high poverty rate for further action (Jean et al., 2016) (Goal 1), support agriculture and provision of food to end hunger (Gandhi et al., 2017) (Goal 2), lead to better health outcome and efficiency of healthcare delivery including diagnostics (Yu et al., 2018) (Goal 3), improve teaching and learning method by offering intelligent tutoring system that tailors to specific student's needs and thus boost the quality of education (Perrotta & Selwyn, 2020) (Goal 4), and enable the design of sustainable smart cities and reduce consumptions of natural resources (Vinuesa et al., 2020) (Goal 11).

On the micro-level, AI can help the market system improve resource allocation and industrial organisation and strengthen firms' competitiveness (Phyrom et al., 2022). Moreover, data and AI are said to reduce information asymmetry, which is a form of market failure allowing the market to reach an optimal equilibrium. In terms of labor market structure, opportunities will arise as new kinds of services industries and businesses, namely e-commerce (e.g., Amazon, Alibaba, eBay), e-payment (e.g., Alipay, PayPal), and social media (e.g., Facebook, Twitter), will also emerge (Phyrom et al., 2022). And with those come new types of employment. It is predicted by the World Economic Forum that about 133 million new jobs will be created by 2025 in several sectors, including Artificial Intelligence, robotics, immersive technology, green technology, and blockchain (World Economic Forum, 2018). In addition, the nature of the employment itself, especially jobs related to software and technology development and multimedia, will be more flexible owing to the fact that now we can collaborate more effectively using an online platform and that workers no longer need to commute to their physical workplace.

But at the same time, questions have also been raised about the possible negative impacts of AI on patients, especially ethical issues regarding how personal data should be treated. AI requires a large amount of data which has gradually become a new oil that can be generated endlessly every day, and such data is handy for many ways and reasons, yet it can pose serious challenges if it falls into the wrong hands or rival countries, and that will compromise national securities along with other dimensions of socio-economic development. Considering the current Cambodian context in which cybersecurity is limited in infrastructure and human knowledge, security breaches should be the top priority. It should be highlighted that AI still needs data, and AI is useless if the data is bad or contaminated by cybercriminals who might use the data to sell in the black market or for scamming purposes because the data is both marketable and profitable.

In addition, increasing the use of big data and algorithms or artificial intelligence in general also means an increase in energy use which may hinder Cambodia's progress toward Goals 7 and 13. The latter is about taking action against climate change by regulating CO_2 emissions, improving energy efficiency, and reducing fuel power consumption. Even though Cambodia has almost achieved universal energy coverage, energy is mostly accessible among the urban population, while the rural population still finds it difficult to gain access to a state-provided electrical power grid. And without stable and sufficient energy, AI might not be useful for rural development, particularly in the agriculture and manufacturing industry, further engendering digital division between rural and urban areas.

AI effects on the Reduced Inequalities (Goal 10) is also questionable, for it is still an expensive technology since data is costly to collect, and expertise in developing algorithms is hard to come by even for developed countries, let alone the developing one. As a result, it is only affordable by the richer countries rather than, the poorer nations, and that will exacerbate the current

inequalities among countries, for the developed states tend to be the ones who can build exorbitant infrastructure to support AI expansion and application, and thus they are able to enjoy more benefits deriving from it. In the case of an individual country such as Cambodia, AI technology is likely to be able to afford only by the rich or major corporations, which tends to increase income inequality. Although AI might help boost productivity, the benefits might not really go towards the poor, creating an obvious two highly divided segments in a single society and thereby social issues. It is suggested that a strong mechanism such as a progressive tax to counter the byproduct or externality of AI should be in placed first.

On top of that, artificial intelligence is likely to place blue-collar workers on the brink of job loss and subsequently increase inequalities within a nation (Brynjolfsson & Mcafee, 2016). It is worth noting that workers need to have decent skills to operate Industry 4.0 technology which tends to reward educated individuals handsomely yet at the same time heavily punish low-skilled workers who conventionally come from a disadvantaged background. This partially helps explain why there has been an increase in the wage gap between college and high school graduates in the United States. Additionally, more automation is translated into less human labor. Hence, AI is likely to reduce demand for but increase the supply of manual workers, decrease their wages, and eventually transfer more wealth from workers to firm owners. In Cambodia, such a structural change in the economy can be detrimental considering that the vast majority of workers in the manufacturing industries, including the garment sector, are low-skilled young adults who are unlikely to utilise AI technology and hence prone to job displacement. It is explicable that there is always a tradeoff between efficiency and equity, but there must be more winners than losers. And the losers should be compensated fairly. In this regard, a process to do so must be considered first before implementing AI technology to ensure that national technology advancement policies are not there only to enrich firms and employers; otherwise, AI-led economic development will lead to even more social challenges. Simply put, it does more harm than good to society. With that said, a valid question should be asked: is Cambodia ready?

Cambodia's commitment to responsible innovation and research ethics provides a solid foundation for integrating AI ethics into its STI policy. By balancing scientific progress with ethical considerations, Cambodia fosters integrity and social responsibility. Upholding human security, addressing bias and discrimination, and promoting transparency and accountability are key aspects of AI ethics that guide Cambodia towards a future where AI benefits society while safeguarding its values.

5.2. Skilling and Re-skilling the Workforce in Cambodia

Technology has been changing the nature of the workforce in all sectors, from small and medium-sized enterprises (SMEs) to big industry, which lead the trends of the new jobs require the 21st century skills (World Bank Group, 2018). It is expected that by 2025, nearly 100 million new jobs

will be created by using digital technology (World Economic Forum, 2018). Emerging technologies such as cloud computing, big data, cyber security, immersive technology, game, AI, cobotics, Internet of Things (IoTs), Block-chain and 3D printing are likely to adopted by industries, businesses, health and well-being, agriculture and education in the future.

It is reported that at least 50% of the tasks (40% of current occupations) are at high risk, and 65% of the jobs the next generation will do in 2030 do not yet exist (Rethy et al., 2019). It is well recognised that there are no ways to tackle the 4th industrial revolution, especially job-loss issues without skilling and re-skilling the AI workforce. In this regard, it is very crucial for government and stakeholders to prepare the digital skill sets for the future labour force. According to Van Laar et al. in 2020, the 21st century digital skills are technical knowledge, information finding ability, creativity and innovation, critical thinking, reasoning and complex problem solving, and interpersonal skills such as communication, collaboration, negotiation and teamwork. With the industrial revolution 4.0, countries around the world, as well as Cambodia have developed their own strategies and policies related to AI. STEM education policy was proposed to encourage students to go for STEM majors after their graduating from high school whereas technical and vocational education and training (TVET) policy and 15-year Cambodia Digital Economy and Society Policy Framework were to promote technical and technology skill development (Ratha & Phirom, 2021). Similarly, to make the existing workforce survive and make it ready for those entering the workplace, the Cambodia's STI Roadmap 2030 and policy focus on improving human capita in science and technology, especially AI in both quantity and quality, and gender equity.

The current highly skilled workforce in Cambodia is still in low number which necessitate an education system reform to prepare in building modern skillsets for the future (World Bank Group, 2018). From the employer perspective, as shown in Figure 3. Skills Gap in Cambodia (Bruni et al., 2013), the most major skill gap is foreign language skills, and practical skills (Bruni et al., 2013). In reskilling and upskilling for the human resource of the 21st century, all education levels need to adapt to AI Education curriculum which AI and digital literacy should have been introduced to our young people since their early age of study. Building up strong background for students in math, English, critical thinking, art, design, animation and coding is crucial in making pathway for them to step foot into the future modern skills (Hör & Hesketh, 2021). In addition to the education reform, to strengthen the future skill sets, it is requiring the participants from all the stakeholders such as governments, universities, industries and societies. To ensure the workforces are ready to meet the future demands of the domestic and foreign labour market, government should give priority to innovative research, STEM education, creativity, and critical thinking skills. Apart from AI and digital knowledge, emotional intelligent skills such as working as a team and communicating with other people are significant for the company well performing, productivity increment, and collaborating with outsiders.
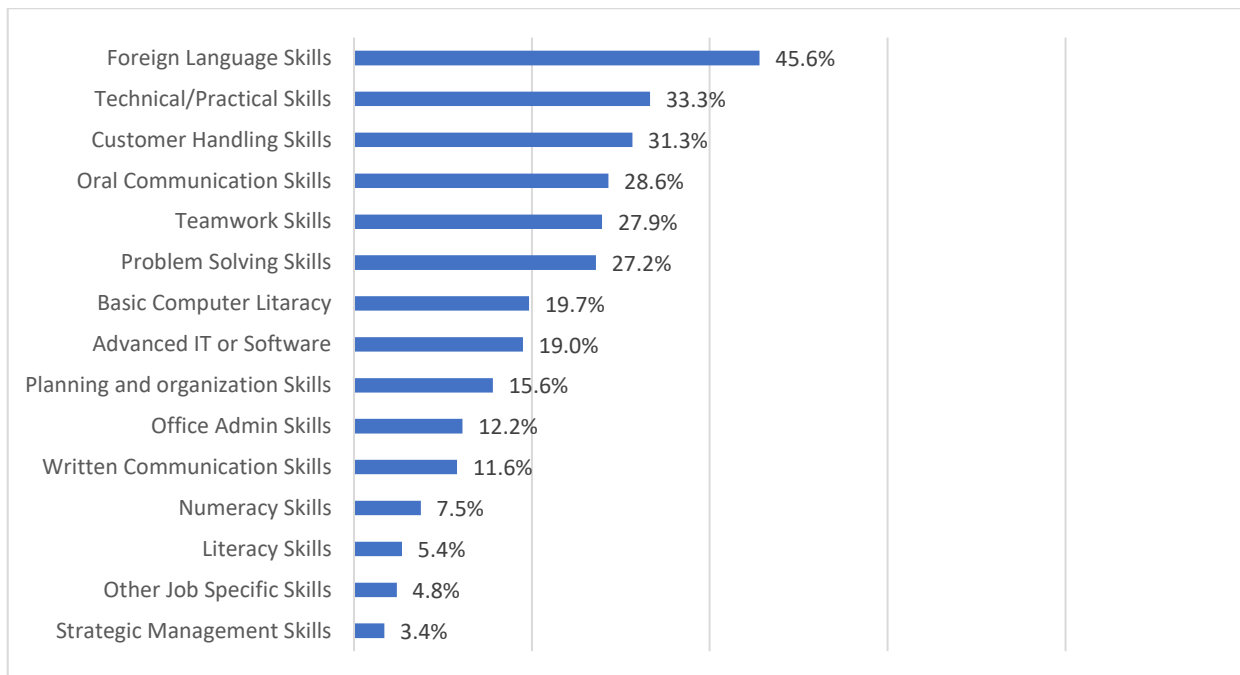
Figure 3. Skills Gap in Cambodia (Bruni et al., 2013)

From the AI workshop (12th June 2021 with all potential stakeholders), the finding indicated that Cambodian fresh graduates lack of both soft skills and hard skills (Hör & Hesketh, 2021). Universities neither transfer such knowledge to students, nor create educational situations for them to acquire these essential skills. In this regard, it was suggested that educational institutions should be in closely relationship with private firms to build good curriculum that match with industry demands. With the partnership, students and teaching will have opportunity to expose themselves to the real-world problem and also staff of the industries can have chance to do research and upskill with the researchers from the universities. From the seminar discussion, to develop new skill sets and upskills for the future work force, there are some recommendations as following:

- Establishing center of excellence to work on advanced technologies
- Building a collaboration framework for knowledge transfer between industries, universities, government and young entrepreneurs
- Conducting regular knowledge sharing session through seminars and workshops
- Proposing strategy and policy to promote job skills for young people
- Creating research and innovation center within the universities
- Developing a directory of specialists
- Developing an AI policy
- Seeking for the source of fund for supporting research and innovation works
- Developing policy framework to captivate youth for new skillsets.
- Skills, Data, and Multi-disciplinary Knowledge Sharing are critical in AI development. Table below shows the major skills and re-skills required for different sectors.

- Three significant challenges that will be needed to exploit full potential of AI applications: data collection and accessibility, inter-disciplinary knowledge sharing framework, and shortage of talent who can improve AI capabilities, stimulate new ideas, and implement solutions.

- To address the challenges, Cambodia can develop the following strategic pillars of AI: i) Centre of excellence for applied research, innovation, training, and implementation, ii) skilling and reskilling of AI and associated workforce with local and global institutional supports, iii) data, knowledge sharing framework and digital infrastructure, iv) GDPR, ethics, data privacy, security, v) funding support for accelerating AI start-ups, research and innovations, and vi) industrialisation/commercialisation/deployment of the AI-enabled technologies.

Table 1. Technology field needed by sectors (Hör & Hesketh, 2021)

Sectors	AI Algorithms	Data Analysis	IoTs	Immersive Technology	Game	Robotics	Cyber Security	Block Chain	3D Printing
Education	X	X		X	X	X	X		X
Industry	X	X	X	X	X	X	X	X	X
Agriculture	X	X	X	X	X	X		X	X
Health	X	X	X	X	X	X	X		X
Business	X	X		X	X	X	X	X	X

The key points to setup a roadmap are as follows:

- Research, Innovation and development capacity building of national human resources targeting a country of innovators

- Promotion of a culture of adopting advanced technologies and AI

- Empower and enable industries for human-machine collaboration to boost incomes and employment

- Dynamic scaling-up for new skilling and align resources with imaginative types of reskilling to prepare representatives at all domains to work with AI-enabled solutions.

5.3. Data Privacy, Ethic, Security and Regulations

While AI promises a positive net benefit for society and economy, it also poses a great responsibility and risk when it comes to privacy, ethics, and security. As one may define AI, it is a machine brain that accumulates learnings from data to create intelligence rather than rules explicitly codified by human programmers to perform tasks automatically. The key here is that the decision is increasingly being made by machine rather than human as it is enabled by data, computing resources, and advanced algorithms. Decisions made by AI could have consequences that affect fundamental rights and human beings. The question is to what extent AI decisions can be trustworthy, ethical and conformed to intrinsic human fundamental rights and values?

- **Overview of the Data Protection and Regulation in Cambodia**

Cambodia has not yet enacted any comprehensive data protection legislation. The first update to the country's data protection landscape has come in the form of the E-Commerce Law (only available in Khmer), which contains provisions for the protection of consumer data that has been gathered over the course of electronic communication. The E-Commerce Law is thereby restricted in scope to virtual and/or digital data protection.

Currently only few laws and regulations that express privacy and data protection include the Constitution, Civil Code, Laws on Telecommunications and the Press Laws.

Ministry of Interior lawyers and data specialists chaired a meeting to discuss the first draft of a sub-degree on the management, use, privacy safeguard and security of data the governments have collected that can potentially be used to identify individuals on January 25, 2021. On January 18, specialists from the ministry's Legislation Council and heads of the ministry's general directorates and departments discussed an initial draft comprising six chapters and 16 articles. The purpose of this sub-decree was to determine rules for the management, use and privacy protections for identifying data that would serve public interests, promote service provision quality and develop the nation in a highly efficient and secure manner.

- **Data Protection and Regulation Vision**

Cambodia seeks to harmonise among the existing laws and rights mentioned earlier for standardisation into a more targeted and specific data protection laws that governs sensitive personal data and its security needs across its lifespans in capture, storage, sharing, use, and archive.

Cambodia desires to balance risks and create conditions for a trustworthy AI sector to grow in a healthy, responsible and safe manner with initiatives to establish a national ethical framework committee body and data regulation laws conformed to the regional and international standards. That way, principles and practices for unbiased use of AI are formed to promote fairness, ethics, inclusivity, transparency, and accountability so that citizens and businesses can adopt the use of AI in a protected and safe manner.

Cambodia recognises risks of heavy regulation seeing regulation may be too strict because it may forfeit foreign investment in the technology sector, especially so in a small country like Cambodia without sufficiently qualified human resources and technological advancement to manage data centres and security at the scale big tech firms are capable of. Cambodia and its citizens have to answer this question as we move into the digital economy: why would large digital technology and manufacturing firms rather invest in Cambodia and not in Singapore or Vietnam? What competitive advantage and drivers do we exhibit relative to neighboring countries in attracting and

retaining foreign investment? Along with an understanding that regulation in nature tends to de-motivate innovation and slow down growth in exchange for a safer and fairer society as regulation increases compliance responsibility and constrains business behaviors to a set of social, ethical, and legal norms especially if poorly designed and implemented. Heavy regulation will likely hurt local digital businesses who emerge to cultivate innovation and experimentation to create new business lines and stimulate growth because they may not prepare to take administrative and compliant burdens, while a lack of regulatory clarity injects fears of heavy fines that could destroy business startup and survival.

Having said that, it is in the nation's interest to establish data protection laws to manage harms while providing regulatory clarity to guide businesses in ways of handing user data and consent, particularly user identifiable information such as name, date of birth, identity, and any other data objects that could reveal an individual identity. Importantly, the world has increased the level of sophistication in digitalisation that captures and processes data across multiple jurisdictions so data protection laws to provide regulatory clarity for cross-border data management and Cloud technology adoption guidelines will be established. Because unlawful and ill intention usage of these data especially by bad actors cause harm to users, and therefore subject to legal responsibilities, penalty and fines. In this effort, Cambodia looks to legislate data protection laws to make businesses and service providers accountable to the management, collection and usage of data in a responsible manner and nurture AI fields for maximum benefits with respect to foundational elements of human rights while promoting adoption for economic gains.

- **Data Privacy and Ethics**

Article 12 of the Universal Declaration of Human Rights treats privacy as a distinct human right. Stated "no one shall be subjected to arbitrary interference with his privacy, family, home or correspondence. Everyone has the right to the protection of the law against such interference or attacks." In the Cambodian laws, it mentioned that citizens have rights to privacy. Definitive meanings to what privacy are remains ambiguous and subject to legal interpretation. However, data privacy often refers to the rights to be left alone and rights to be free of independent thoughts. Even so, privacy is a broad term that is essential to human dignity and autonomy for individual freedom. Yet when conflicted with other laws, rights to privacy may be restricted under certain conditions like to protect national security and public safety. For example, in the matter of criminal offenses to protect public safety the state may authorise and require persons or entities to reveal one's individual identity without the needs of the user's consent who is under suspicion.

In this regard to the privacy needs of citizens, Cambodia looks to establish a guideline to encourage organisations of all sizes to adopt privacy-by-design approach to developing AI applications while the establishment of the National Committee of Ethics will champion the guidelines and direction for the incorporation of ethics and privacy for AI. Given how early-stage

AI is in Cambodia and for many organisations of all sizes, it may be impractical to copy and paste regulation requirements from the likes of European Union's General Data Protection Regulation (GDPR). A customised and localised standard data privacy and protection laws will be likely to align with the ASEAN regions. Basic elements like the collection of personal data shall have user consent and provide purpose information to such usages that protect user privacy and security. Individuals shall have rights to request, access, update, and remove at its user cost.

Cambodia sees AI development conform to the ethical framework and social norms to ensure human values are protected, inclusion is encouraged, and fairness is preserved without systematic discrimination against humanity that causes perceptual bias and harms. The discrimination may be classified into a category of race, gender, physical ability, and economic background. Right protection to equitable, just and fair treatment in society is a fundamental responsibility of the state when it comes to inter-relation conflicts among individuals, businesses and government agents. However, it is the responsibilities of the organisations and/or goods and service providers that create AI applications and mismanage user data that affects one' ethical values. Decisions made by AI applications that affect society's fundamental and ethical values shall be thought out by design and undergo a standard user and system acceptance test aimed at ensuring a Trustworthy AI. Critical decisions whether in health, credit loan, insurance claim, and employment shall provide reasonable explanations to support why such decisions are being made. When in doubt, humans should be in the loop to ensure AI decisions behave as expected and trusted. And AI decisions are ethically sound and have a base of ethical foundation aligned to Cambodian constitutions and ethical framework.

- **Data Security**

Data security is the process of safeguarding data against unauthorised access and corruption throughout its lifespan from data collection, sharing, usage, and deletion. With the growing risks of cyber attacks and intrusion, organisations adopting AI at any scale shall invest to build cybersecurity capability in human resource and security technologies to govern, protect and manage its data assets. Data security methods such as data encryption, hashing, and tokenisation are essential to the way data is safeguard and protected across all applications and platforms. Because management of user data is ultimately the responsibility of good and service providers, security governance and checks shall be in place to protect user information from cyber security attack, leaks, scams, fraud, and loss. Risks of cyberthreats shall be studied, assessed and minimised at the organisation disposal. The intended or unintended consequences of poor management of data may cause various harms to users so corporate organisations who handle large personal data especially related to personal finance and health shall be accountable and able to demonstrate compliance reporting. The organisation shall have at least a minimum of one key person in charge of creating and mandating its data policy, security, and governance.

In general, Cambodia desires to establish data protection laws and guidelines to provide regulatory clarity for all data processes across its life spans and to protect users with regards to data privacy and ethics. Service providers shall adapt to a human rights by-design approach to minimise unintentional or hidden biases, any discrimination or other negative consequences on individuals with respect to human rights and basic freedoms. The government of Cambodia aims to design a well-informed regulatory framework consisting of best practices in the growing subject of Trustworthy AI, while emphasising the need of using AI in a fair, transparent, accountable, and responsible manner.

5.4. Strategic Investment for AI-Powered Cambodia

After a series of up, down and side turns, the development of AI technology has made great progress globally emerging from research labs into more socially useful and commercially viable technology applications that present massive opportunities for a modern economy and society. Some refers to AI impact and disruption from the change and technological innovation to the early days' invention of electricity, steam and water as well as the automobiles, computers and the internet today.

With billions of dollars expected to generate from AI globally, Cambodia sees the need and urgency to invest, adopt and prepare for this AI global force in line with Industry 4.0 trend as the economy increasingly becomes knowledge and digital based. A strategic investment in the field of AI introduces three major pillars to maximise benefits and minimise risks in the facilitation of AI development for nation-wide adoption, safety and sustainability:

- Invest in people - building the nation capacity for a resilient workforce, growth and innovation
- Invest in technological infrastructure - building a robust foundation
- Invest in a collaborative tech ecosystem - building a sustained network of value providers.

These strategic views aim to drive Cambodia's competitiveness in the region and attract foreign investment. As a small, growing nation rising from ashes, Cambodia is not yet in a position seeking to be a leader of AI in most domains but to strengthen its emerging role to contribute to the global economy as a hub for applied AI with young people talents to rapidly and innovatively prototype solutions to solve state-level, societal and economic problems. An investment in human capital, digital infrastructure, and ecosystem development help Cambodia maximise gains at every stage of development and adoption, while R&D in niched areas are encouraged to be innovative and pioneering. The investment in R&D also prevents critical adoption barriers and accelerates the use of AI for economic and societal benefits. For example, without investing in the core Khmer NLP Cambodia cannot maximise its benefits from AI applications like

conversational chatbot using Khmer and any others that build on top of NLP requiring the native language. Cambodia also aims to establish a data protection regulation to provide regulatory clarity and ensure accountability for a trust worth AI to flourish responsibly that is in line with ASEAN and international data protection laws as well as conforms to the established social norms within an ethical framework with respect to human rights.

5.4.1. Invest in people - building the nation capacity for a resilient workforce, growth and innovation

This is in line with section 5.2. Skilling and Re-skilling the Workforce and the Rectangular Strategy IV from the Government of Cambodia. It looks to refine its positioning and competitiveness in the regional play. Needless to say, AI will disrupt and impact labor employment categories, which require strategic initiatives to facilitate labor mobility, rapid skills building and upgrading, skills transfers, and access to information. One of the greatest assets Cambodia has is its tech-savvy young population, where almost two-third of the population is under 30 years old. More and more young people are equipped with English speaking ability which will serve the needs of digital knowledge workers in the new era and in the ASEAN Economic Integration for labour mobility and interaction. By leveraging the rising young, talented individuals and tech startup entrepreneurs to build Phnom Penh digital hub for innovative applications, technology and data talents, Cambodia is prepared in human resource development to achieve higher middle-income status by 2030. People capability development is not only to build a home-grown young workforce sufficient to supply the country's economy but also the regional and international economy. A number of factors are key considerations when it comes to AI talent development.

5.4.2. Mindset and literacy

The government of Cambodia recognises building capacity for the labor workforce is a long-run effort. Any change management starts with mindset - themselves, their family and institutions. The government aims to raise awareness and educate the population about the potential uses of AI, benefits, and its risks. This introduction aims at raising the national average level of digital literacy around basic technology usage so all segments of citizens including disable persons, lower-income group, female and elder can reap full benefits and not be digitally excluded. As AI becomes more prevalent, relationships between humans and machines will also need to develop and strengthen for a safe, knowledgeable, and growing society. Digital literacy programs around AI and STEM education will be campaigned and promoted targeting 1) the general population 2) parents for their confidence in job prospects of their kids' decision to enter STEM education 3) youths themselves to be aware and access information as they make informed educational decisions. The government will also look into policy design for promoting the demand side for AI and digital talents to power their institutions in both private and public sector such as tax credits for workforce training, and in particular act as the public-private collaboration and protection

enabler to increase private sectors' incentives for maximum impact and reduce frictional risks for a striving digital economy. All initiatives will be to ensure digital mindset, literacy, and attitude toward AI are well received and cover both the supply and demand side when it comes to human resource planning and development.

5.4.3. STEM graduates

A strong and growing economy highly correlates with STEM education as it serves to build labor forces to fill needs from the private and public sector. More importantly, with the applications of AI, STEM workers will need to think, build, operate, and maintain AI. Critical preconditions like this for the AI sector to flourish in Cambodia will be explored, assessed and acted upon to build a robust local talent pool in the field and overtime change the dynamic of foreign talent dependencies. Cambodia has made and continues to level up its effort to increase the number of STEM graduates per year working with the Ministry of Education, Youth and Sport and in building early age interests of children toward STEM education, ensuring a sizable enrollment and minimal drop out in universities across city and provinces later on.

With the recognition of the needs for practical lab and applied studies, Cambodia aims to foster and promote public-private partnerships such as employers and education institutions to establish internship standards that mutually benefit both the students and organisations. This effort is intended to establish educational and employment links and create more chances of success, for example with government sponsored local and international internship programs in the STEM areas which will be shared, promoted and standardised. Sending students abroad for STEM internships will give them practical experience and exposure to the international work environment and standards while keeping brain drain in-check. Collectively, it drives international competitiveness for employment opportunities when it comes to quality talents for local and international employers. Along with productivity gains expected for the economy with STEM graduates, their income is also expected to rise drastically into a new income bracket thus leveling up a multi-generational, socio-economic impact to them, families and society.

5.4.4. TVET graduates

Beyond a STEM degree program, a new TVET education focusing on ICT are welcomed and promoted to complement university degree standards. Companies expect graduates to come with soft and technical skills that reflect the changing nature of industry and technology so require a rapidly evolving and regularly updated curriculum for quality teaching and practical excellence. A number of classroom-to-career institutions will be promoted to provide short-term, high skills, industry-relevant technology training to meet the rapid needs from private sector organisations and SMEs. Cambodia aims to support these specific skills development programs especially in

the digital and technology fields such as but not limited to computer training, AI, software engineering, blockchain, robotics, data science, computer programming, and cyber security.

5.4.5. Life-long learning for upskill and re-skill workforce

In addition to these above education standards, Cambodia looks to develop life-long learning opportunities in its efforts to upskill and re-skill both private and public sector staff. Cambodia intends to explore e-skill credits where individuals can apply and use the credits with third-party providers to receive the training, developing their resilient adaptation to the inevitable force of automation and preparing for new job category creation by AI. Overall the life-long learning initiatives will increase citizen professional growth opportunities for better employment and higher income while boosting the nation's productivity. The impact of job loss and creation due to AI will be carefully studied in the context of Cambodia and plan initiatives for rapid upskill and reskilling implementation programs working with key multi-stakeholders including international development organisations and training providers. Cambodia has witnessed the impact of Covid19 pandemic that destroyed by-and-large the tourism sector that the economy has largely depended on. This major source of income powering the economy has been depleted with great uncertainty moving into the post-covid era. Garment manufacturing sector, which has also significantly contributed to Cambodia's GDP, is another area greatly vulnerable to the global development of AI, high-tech investment and automation. It is a national concern that has been shared among key ministries and development partners. Having said that, Cambodia works proactively to take calculated risks, minimise the expected damage, and cultivate opportunities that AI will create such as through the upskill and re-skill efforts to ensure a positive net impact from AI.

5.4.6. Invest in technological infrastructure - building for a robust foundation

Digital infrastructure is the backbone of a thriving economy for the internet era. A strong digital foundation is essential to maximise the benefits at scale with minimal security risks for vibrant and safe technological development in society.

5.4.7. Connectivity and telecommunication

Cambodia enjoys a high mobile and broadband penetration rate. Telecommunication services are provided with national-wide network coverage at affordable prices for customers--partly thanks to a regulatory environment that fosters market competition among mobile operators. Advancement in telecommunication technology such as the introduction of 5G infrastructure and fast-speed fiber optic will also further increase the nation's connectivity. While a high penetration rate of mobile phones and connectivity coverage is well acknowledged, Cambodia government will continue a regulatory environment that promotes investments to better telecommunications

networks and services that support AI research, applications and usage. Particularly it aims to boost connectivity infrastructure further and promote public-private partnerships among hardware manufacturers, internet service providers and interested economic actors to increase household access and affordability for available hardware devices and fast-speed, high quality internet connection thus increasing citizen participation in the digital economy and reap potential benefits.

5.4.8. Digital and data infrastructure

In line with the 5.3. Data and Digital Infrastructure section, strategic investment into building a robust data and digital infrastructure ensures Cambodia facilitates the development of the AI sector. Any AI R&D requires storage and computing resources to be utilised in a collaborative, safe and secure manner. Cambodia will support the digital infrastructure architecture with high-performance physical servers and software in preparation for the country's ambition toward a digital economy and create a digital sandbox for innovation and collaboration among private sectors and research institutions to prototype solutions to societal and commercial applications of AI. Cambodia aims to develop a national data center facility to manage computing, data storage and network services to ensure smooth operation. Initiatives will also be taken around boosting the quality and access of the high-performant internet, computer network, security system, data center, social media, software, mobile and web applications.

5.4.9. Invest in the emerging technologies

Cambodia government embraces digital technologies as we've seen in the industry 4.0 agenda for e-government adoption at the state-level because it believes ICTs enable innovation for the country and not stifle it. The gap between the current pace of global technological development and adoption ability in Cambodia is increasingly widened for many areas; only a few niches where we are noticeably recognised as early adopters. These niches can be said for the case of the Bakong blockchain-based technology system by the National Bank of Cambodia as among the first central banks in the world to deploy such revolutionary tech. The technology facilitates the settlement among financial institutions and lowers the cost of inter-cooperation for all end-users thus increasing financial access and inclusion. Another case can be said for the ID-Poor on-demand digital system and graph database by the Ministry of Planning working with key development partners such as Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH and Australian Aid to better social registry and social protection with targeted assistance provision to the right poor households. These technologies are newly adopted in Cambodia and have not been done at the same scope or scale before but have shown great promise, feasibility and nation-level impact; thus for the digital ambition that Cambodia strives to achieve will require investment into testing newly emerged technologies, fostering a culture of trial-and-error experimentation with more collaborative R&D institutions, and building a know-how absorptive

ability for the nation to scale up the implementation efforts. Some examples of these emerging technologies include distributed big data storage with Hadoop/Spark for a single source of identity information, decentralised applications with blockchain around ownership rights and data traceability with a security standard, Internet of Things such as drones and robotics to better agricultural output, digital platforms for e-services to increase citizen and business participation, cloud computing integration technologies with regulatory clarity and feasibility assessment to enable business organisations' accessibility for the world's powerful technological infrastructure and platforms to increase their productivity output per unit cost of production.

5.4.10. Invest in a collaborative tech ecosystem - building an ecosystem for a sustained network of value providers

Cambodia has the opportunity to achieve economic, security, and social gains in the AI sector for many domains. Yet it lacks key enabled and supported areas. For example, for e-commerce to function in the economy, which has taken a long time until it is being adopted more widely now in its growth acceleration partly thanks to the e-commerce law enacted in 2019, it requires not only the digital marketplace for buyers & sellers, but also logistics, digital payment, and customer protection that facilitates it. It is nearly impossible for any individual business to build every aspect at the same time thus relying on an ecosystem of various economic actors in the provision of products and services. The Cambodian government has made big steps and is committed to promote a robust collaborative ecosystem to increase overall benefits and reduce collaboration cost for the ecosystem actors.

One area is in the promotion of a vibrant startup ecosystem and tech hub supported by a local and international collaboration. For example, the co-investment initiatives with private institutional investors increases access to finance for startup and SME entrepreneurs with Khmer Enterprise's Entrepreneurship Fund by the Ministry of Economic and Finance. It also brings a well-known global VC (Startup 500) through its international collaboration and local corporations' partners to nurture the startup ecosystem. Tech entrepreneurship is demonstrated as a career path option which is actively promoted in addition to STEM workers. Cambodia encourages economic activities and initiatives that drive the next generation of digital businesses and startups that use digital and AI technologies through national award, grants, and investment.

5.5. Research and Innovation

This section explores the state of the art of research landscape in Cambodia about AI. More importantly, the innovative aspect of the knowledge from AI research will be discussed in the context. At this point, it is important to root the term "innovation" viewed by Charpie in 1967. He emphasised that innovation is made if five steps are made, which includes basic invention from ideas (ideation), engineering design (micro piloting), manufacturing (industrial scale),

manufacturing startup (making a startup), and market diffusion (generating profit). AI will be ubiquitous in our daily life in next decade, especially in decision making process, improving workflow and efficiency, health care, education, and financial sector. For instance, it is suggested that AI capacity will surely add value to the efficiency and accuracy of clinicians (Thomas et al., 2021). Data will be the driving for AI development. Internet users are the main contributor of data for AI. The materialisation of AI stock of AI knowledge for economic purposes is an innovation approach. Contextually, Cambodia requires strategic investment in the field if the kingdom wishes to unleash the potential of AI for socio-economic development. Some important investment could be financing, infrastructure development, talent development, and supportive regulatory framework. Three types of data are being collected for AI, which are identity data, network data, and behavior data (Ma, 2021).

- **Identity Data** refers to data of individual, entity, or identity or information characteristic to identify a person or institution.
- **Network data** refers to data of location from direct input to any application or usage of any particular application.
- **Behavior data** refers to data that users browse in websites, social media, Apps or in other application interfaces

The three data are the important resources for AI. A triple helix model of market driven research on AI could be reiterated most of the discussion. The world is facing the rapid accumulation of knowledge on AI, while private sector is harnessing the potential of the field. However, consequences and various potential risks arising from this development has posed a great attention among policy makers and academic researchers, while private sector is in concern stage to materialise the development. Likewise, Cambodia is experiencing the rapid development of AI in the last decades. The pool of knowledge in the field is growing fast in way that is unpredictable from user perspective. Practically, academia is seen to have challenges in coping with the demand of private sectors in the field. This rapid development and application of the field in industry/services results in great attentions as well to policy makers. Government regulator has generally acknowledged the significance of AI in economic development, but privacy, security, ethics, and value are the major concern. After all it is necessary that AI landscape in Cambodia could be well understood prior to incentivise or regulate the development of the domain.

5.5.1. Scholarly publication

From academic point of view Cambodia has seen the importance of investment in AI development. Some nascent publication of AI by Cambodian scholars seems to be since 2004. For instance, the first algorithm on swarm intelligence published (Hul et al., 2007a; Hul et al., 2007b; Seingheng et al., 2007; Tan et al., 2008). The work was published focusing mainly on water reuse/recycle in industrial sector. However, it seems no much progress in scholarly work, despite that the work

has great attentional in the later stage. Supper power economic drive like China, European Union, and United States has started to invest drastically in the research and development of AI from that time. The number of peer-reviewed paper and patents on AI has increased significantly in the last decade. Most of the papers are coming from higher education institutions. The number of AI publication including journal articles, conference papers, repositories, patents, book chapters, book, thesis, and others are show below. The number of AI publication is seen more than two folds in the last ten years. The report by Center for Security and Emerging Technology in 2022 appears that journal papers share 51.5% of all AI scholar documents published. Pattern recognition contributed more than other fields of machine learning, computer vision, algorithm, data mining, natural language processing, human computer interaction, control theory, and linguistics.
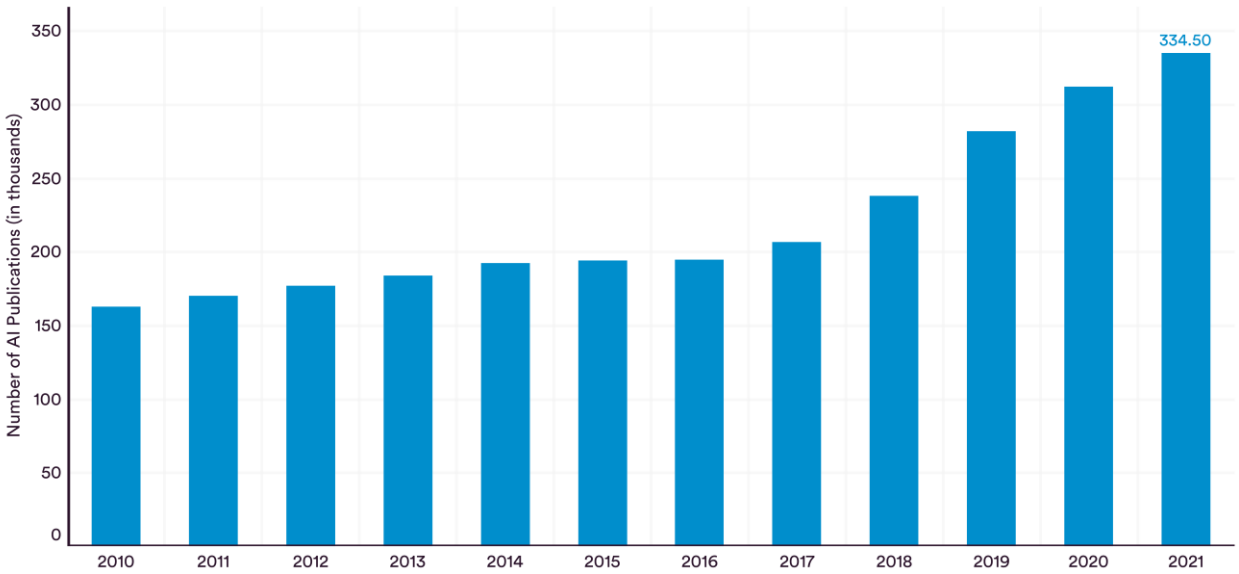
Figure 4. AI publication trends in the last ten years (Center for Security and Emerging Technology, 2022)

AI publication by sector shows that education predominate in the last ten years, while China shares largest number of publication and citation about AI. The huge contribution of AI knowledge from China could be attributed to large amount of data from users and the government policy to support the AI development in the country. In addition, hundreds of companies are opening up on AI investment.
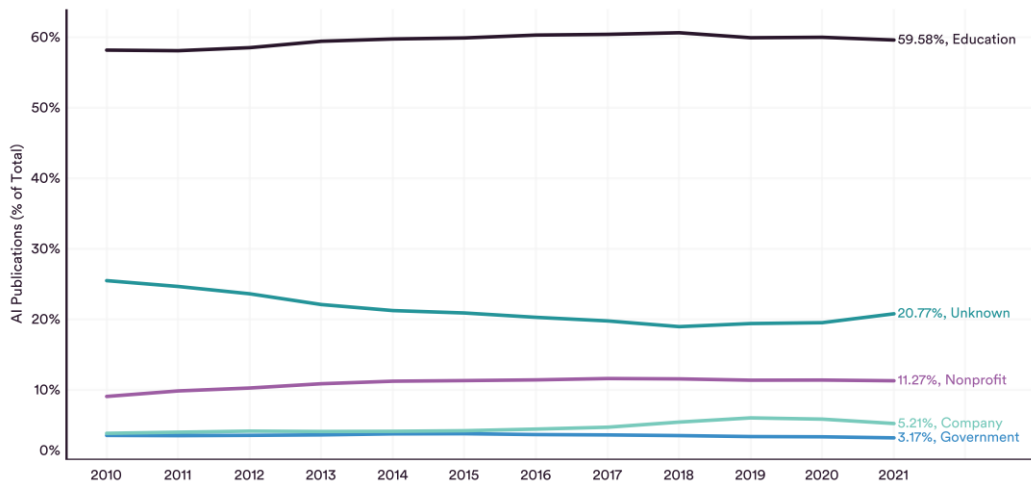
Figure 5. Publication by sectors in the last ten years (Center for Security and Emerging Technology, 2022)

Trends has commonly understood that AI-driven technologies are expected to be the stimulus for economic growth. Likewise, Cambodia values the importance of AI application as well. However, adoption, implementation and incentivised system are not sufficient enough from academic studies in Cambodia society (S. Heng et al., 2022). Scholars put an importance debate on value of AI on economic development. Some suggested that AI-enabled technologies for economic development in emerging growth nations could not simply happen until there is proper ecosystem. The foundation to adopt and adapt AI technologies for developing economy could be scientific/engineering-based education, sufficient infrastructure, favorable technology transfer mechanism, and others (Sayogo et al., 2020). Further investment on AI-enabled technologies in education sector was also suggested (P. Heng, 2019). One of the first academic events was conducted entitled "1st annual forum on AI: Human intelligence in augmented era" with the aim to promote the field and its application. The event was arranged by Institute of Technology of Cambodia and Cambodia Development Resource Institute. Then, the forum was not made possible due to disruption of Covid-19. Finally, this important event was continued to commence again entitled "2nd annual forum: AI for Society" on August 10, 2022 at Cambodia University of Technology and Science in collaboration with Ministry of Industry, Science, Technology & Innovation.

This forum is organised to bring academia, private sectors, government, civil societies, and other relevant stakeholders to discuss the current development of AI, its future trends, and opportunities and challenges up ahead that Cambodia should prepare itself for if it decides to fully embrace such technology. The forum has five main objectives:

- Provide a platform for the representatives from the government, industries and academia to discuss, express, and exchange ideas on the AI landscape and its impacts on society

- Raise public awareness of the significance, opportunities, benefits and challenges of AI applications
- Formulate policy suggestions and recommendations for promoting and strengthening the development of Industry 4.0 technologies in general, AI in particular
- Promote multi-stakeholder collaboration for knowledge mobilisation and development of artificial intelligence in Cambodia
- Disseminate the results of research studies on Artificial Intelligence Landscape in Cambodia.

5.5.2. AI Demand

The application of AI is necessarily incorporated in industry and related public services. There is a need in synergising efforts from all stakeholders. An investment in AI for research universities is important. On the other hand, the private sector and public institutions could bring actual AI-enabled technologies to fit the demand for research universities. Research and innovation ecosystem of AI in the countries could be suggested as fellow (S. Heng et al., 2022).

- University level: Required motived and qualified researchers on AI, intra and inter collaboration among researchers and institutions, lessening redundancy work, Joint research efforts
- Private sector level: Setting up task force, using case-driven approaches, solution-driven adoption process
- Government level: Required funding for research and development, clear approaches and strategy, centralisation of the AI activities.

Coordinating underlies foundation the AI research and development. Existing policy such as National policy on STI 2020-2030, Cambodia's STI roadmap 2030, Cambodia Digital Economy and Society Policy framework 2021-2035, could be some of legal instruments to unleash the potential of AI for useful purposes. Breaking the silo among all stakeholders is the immediate actions to ensure that AI ecosystem is connected for socio-economic development of the nation. National council of science, technology & innovation is the big umbrella serving as platform to accommodate stakeholders.

5.6. Potential AI applications for different sectors

5.6.1. Service

Over the last few decades, the number of internet users increase rapidly over the world wide web. In the current era of internet, large amount of data has been generated every day whenever you are watching TV, using social media, doing online shopping and communication. As the speed of internet access is getting incredibly faster from end-to-end users, the new advance technologies

such as IoTs, Big data analytics, AI, have been possibly introduced to better benefit the human life. Due to this reason, numerous of companies seek to adopt these advance technologies to create more creative services from day to day to their end user. This process could be possible by collecting and analysing the data generated from the past experience of their customers and, thus, it could deliver the related services according to their interests and needs. Let's take a look on how the AI technology has the impact on everyday life as following:

a. Retail and E-commerce

With the development of the e-commerce, the scale of online retail is becoming larger and larger. Within the variety of product categories and changeable customer demand, it is a very big challenge for the sale volume prediction. In the modern day, AI is applied to tackle the aforementioned problems. Chen in 2020 proposed an online retail prediction using machine learning called AGA-LSTM Neural Network. The adaptive genetic algorithm is applied while the building of neural network to optimised the training time and prediction accuracy. As a result, the method could forecast the sale volume of goods in a very large and complicated e-commerce.

b. Online Advertising

In the world of the digital marketing, many companies try to improve their business strategy by promoting and diversifying their products and services via many methods and one of the promising one is online advertising. The problem is how does the company actually know about which ads the customer is interested in. In fact, AI is already there to solve this problem. Normally, most of the website have implemented the tracking code to keep log file of browsing behavior of individual (Neumann, 2016). This information is shared across different companies and, thus, the historic behavior about the user interest of which site you visit or which product you looked at were being captured. During this process, AI is used to match the users to the corresponding ads based on the analysing of this historic behavior.

c. Customer Support

Customer support is the very effective way used in any company to help the customer when thing goes wrong e.g., when user want to know detail about the way the use the product properly, they would call and ask. Traditionally, most companies spend a lot of moneys to create customer service department as the prompt and accurate response to a request is very essential for customer retention and satisfaction (Molino et al., 2018). Yet, this procedure could lead to change of worker practices as the users expect to ask for time availability of the information about their orders or to answer a very simple questions such as "why is my internet connection dead" (Hardalov et al., 2018). Many of AI application have been proposed such as voice recognition, sentimental analysis (Kaur, 2018), etc, in order to understand the customer's question and give

the accurate response e.g., nowadays, people are most likely to use Alexa, Siri or google assistance for online shopping, controlling home devices etc.

5.6.2. Manufacturing

Manufacturing sector has played an important role for the country by contributing to employment growth, national security, sustainable development which improve the economic potential and GDP of the country. With the emerging technologies such as inter-communication (IoT, CPS), smart visualisation and decision making (AI, Big data, Cloud Computing) and Cyber security   it has enabled the transformation of the manufacturing in terms of the model, approach and its ecosystem. The life cycle of manufacturing in the new era requires a lot of processes and technologies. Generally, the procedure uses the autonomous sensing, inter-connection, decision-making, control, and the execution of human, machine, material, and environment information to integrate and optimise various aspects of manufacturing. Therefore, it would help to facilitate the production flow and to produce high efficiency and quality, cost-effective, environment friendly for users, and to improve the competitiveness in the manufacturing market. In addition (Qu et al., 2019), the evolution of smart manufacturing is not only to develop new technology, but one must also define the requirements of stakeholders and the model of innovative business. Technically, this process would help get real-time data to improve the accuracy of decision-making in the supply process (Mass Customisation), enhance the efficiency and performance of the production line process (plant automation), minimise the used resources (raw material), waste management and increase the overall productivity. AI, which is computer system able to perform task that generally mimic to the human intelligence, is one of the main key drivers in this change as it would help in forwarding the sustainable development (Buchmeister et al., 2019). Thus, AI is a very important factor to transform the traditional manufacturing into advance and smart manufacturing in the context of fourth industrial revolution.

a. Smart Warehouse management system

Traditionally, warehouse is used to store the manufactured products from one or many places and deliver them to the company customer. Due to the rapid increasing amounts of orders in the modern day, the distribution process in the warehouse is getting more complicated and led to the birth of the smart warehouse management system. According to study there are five main steps in the complete product distribution process which consists in planning, receiving and put away, location management, order picking and packing, and transport and tracking. By introducing AI concept, each step can be analysed and optimised separately (Žunić et al., 2018). Study by Pulungan et al. in 2013 provides some brief discussions on the practical implementation of artificial intelligent into warehouse management system. The research mentioned on how to use new technologies such as bee colony optimisation, fussy controlling, extreme learning machine along the Radio Frequency Identification. All of the aforementioned technologies are used to

enable the intelligent logistic system, intelligent warehouse system, real-time transportation monitoring system, sales forecasting system and intelligent sales summary system (Pulungan et al., 2013).

b. Manufacturing Production

Since the beginning of the industrial revolution 4.0 (I4.0), many countries have already address it as modern challenge in various fields especially in the advance industrial manufacturing (Kagermann et al., 2011). This transformation of advanced industrial manufacturing could be made through digitalisation and exploitation of new advanced technology such as self-learning and self-adapting cyber physical system (CPS), IoTs, cloud computing and AI. Their primary goal is to address the need of modern production system with higher efficiency and lower cost throughout the process so that it could meet new demand in the modern market. To tackle the problems, numerous of enterprises have already investigated and implemented by using all of these aforementioned technologies. To be competitive under the paradigm of I4.0, a company must production planning and control (PPC) able to respond to disturbance (Cadavid et al., 2019). Normally, PPC can be defined as the required quantity in the plant production to meet profitability, productivity and on-time delivery. To satisfy the requirement, the author introduce the AI technology by using text mining to estimate the production inhibition time and machine learning techniques to create the dynamic production schedule in the production line. On the other hand, the aim of smart manufacturing is to achieve highly flexible and automate in the production process (Hsieh et al., 2019). The use case of the paper is to detect the anomaly of production line in smart manufacturing by using the collected data from the sensing device. They introduce a new AI algorithm called unsupervised real-time anomaly detection based on LSTM-based Auto-Encoder.

5.6.3. Mobility and Transportation

Mobility and transportation are known as the backbones of the modern economy and function in one country to become intelligent. They are a driven force to promote economic growth, enhance the accessibility of the labor market, strengthen the logistics supply chain, and open up new markets for enterprises due to their linkages to other sectors. According to the Japan International Cooperation Agency report on the modernisation of vehicle registration in 2019, the number of registered vehicles and motorcycles has increased exponentially. The growth rate in 2013 was approximately 84%. This growth leads to primary emissions, then the smart moves of the mobility and transportation sector must be required to achieve environmental sustainability and a new mobility ecosystem.

New mobility and transportation technologies currently take AI as the significant perspective, transforming conventional transportation into intelligent transportation. The potential AI applications on mobility and transportation can be enabled as follows,

a. **Advanced driver assistance systems and automated driving systems:** this autonomous technology can enable vehicles, trains, roads, and other infrastructure to communicate with computers, smartphones, or other devices via wireless technologies. AI capabilities can help increase safety, reliability, and hauling efficiency. For example, autonomous driving systems are designed to offer drivers some functions such as monitoring, warning, braking, and steering functions. The potential of AI can be analysed to predict the end of the queue to generate a queue warning message to allow the vehicle to take action.

b. **Cybersecurity:** AI is built in cybersecurity to provide high security of cyber technologies applied in modern transportation to achieve efficient operations and prevent any thread interruption. Precisely, those automated systems that connected vehicles, devices, and infrastructure operating together are needed to embed AI technology to ensure the confidentiality, integrity, and availability of the systems by identifying the threads/malware, preventing the damage resources.

c. **Accessible transportation:** This system uses AI to support all travelers, including the elderly or people with disabilities. The system consists of many target functions related to transportation, such as pre-trip planning, wayfinding and navigation, surface street crossing, and navigating the complex road. In addition, the auto curb ramp system is also installed in the vehicle or other transportation as an assistant to help the disabled and older adults. AI can also promote reliability and safety execute one travel to all links in the travel chain to make it easy for users to access.

d. **Traveler decision support tools:** The potential AI-enabled applications provide adequate monitoring information to process passenger requests (weather/pricing information), predict the roadway, arrival times, and other valuable functions such as planning trips. For instance, the transportation system managers can also use the information in the system to support decision-making.

e. **Transportation systems management and operations**: The optimisation of multimodal infrastructure systems using AI is built to perform real-time and dynamic service systems to improve the transportation system. Decision-making is also considered in this management system to control the work zone, traffic incident, road weather, or other traffic signals.

f. **Commercial vehicle and freight operations:** AI is embedded to address the operation and movement of vehicle and freight management systems. For example, AI is applied in asset tracking, cargo status monitoring, freight optimisation, freight signals, etc., to ensure management efficiency and safety.

g. **Transit operations and management:** This system uses AI to perform the management, operations, maintenance, and security to respond to many services, including maintenance forecasting, event detection, dynamic itinerary planning, and service allocation. This system helps the user monitor and select the service to apply for transit vehicles.

h. **Emergency management:** This is a particular system that uses AI to build the alert agency system to address public transportation safety management. The system covers the necessary alerts, such as policies, fire, and emergency medical.

i. **Air traffic management:** To optimise air traffic pathway management, AI needs to use the available data to generalise the pathway and provide real-time visualisation of the traffic management system.

j. **Remote sensing**: Drone and uncrewed aerial vehicles have functioned as intelligent remote sensing, which uses AI to monitor and control the traffic, bridge inspections, aerial mapping, incident management, and transportation infrastructure.

k. **Asset management and roadway construction and maintenance:** This system focus on the strategic and systematic process of operating, maintaining, and improving physical assets by using AI application. The prediction of AI can identify a structured sequence of maintenance, preservation, rehabilitation, and replacement actions that requires taking action at a minimum feasible cost.

In summary, there are four system functions enabled by AI in the mobility and transportation sector:

- Sense and perceive the environment
- Reason and analyse information
- Learn from the experience and adapt to new situations
- Make decisions, communicate, and take actions.

The AI-enable application is checked with four maturity levels: concept, R&D, prototype or minimum viable product, and production. Consequently, there are three aspects of AI-enabled application:

- The increased levels of comfort and convenience

- The prospect of vastly improved safety through autonomous driving
- The macro benefits to the environment (e.g., potential reduction of emissions) and society (e.g., potential optimisation of traffic flow, less required parking space in city centers).

5.6.4. Agriculture

The agricultural sector is one of Cambodia's 2030 roadmap priorities for technology development options. Besides, agriculture had gained 22 percent of Cambodia's GDP and employed about 3 million people in 2018, according to a report by the US Embassy in Cambodia. Currently, agriculture technology has rapidly transformed to use advanced machinery and internet of thing technology to analyse and enhance production efficiency. The potential AI applications in the agriculture sector can provide into six categories:

a. **Agricultural production management:** AI is enabled in the agricultural production management system to provide information about crop rotation planning, planting time consumption, water and nutrient management, pests and fertilisers and management, disease control, optimal harvest, food marketing, product distribution, food safety, and food supply chain tasks

b. **Agricultural production management:** AI is enabled in the agricultural production management system to provide information about crop rotation planning, planting time consumption, water and nutrient management, pests and fertilisers and management, disease control, optimal harvest, food marketing, product distribution, food safety, and food supply chain tasks

c. **Crop monitoring:** This system applies AI to monitor and identify crop health issues, soil nutrients, weather conditions, irrigation, and other functions that maximise crop revenue. The AI-enabled application provides visual instruction and quickly understands soil health, plant pests, and plant disease

d. **Data science:** The agriculture information is stored at all data points every day for further analysis. For example, weather conditions, temperature, irrigation, and soil conditions data are collected from the farm to enable an AI model to predict the plant condition whether it will produce high quality or not. Real-time data provides a better understanding of the health of plants and optimise natural resources. This approach produces agroecosystem dynamics under changing environmental conditions

e. **Disease detection:** The AI-enabled tool is applied to provide the early-warning system to prevent disease outbreaks and spotting insects/animals in the area of plants. AI can also trigger the sensor to take action to protect the plant

    f. Food quality: Food safety and quality assurance use AI as a critical role to perform most human tasks to check the plant

    g. Predictive analytics: The potential AI application is performed as data analysis to help farmers protect the land quality, reduce water irrigation, and determine the amount of crop harvested. The prediction is expected to increase the profitability for each field while reducing the environmental impact of pesticides and fertiliser.

In summary, AI will drive the agricultural revolution to an intelligent agricultural ecosystem and sustainability.

5.6.5. Education

Throughout the ages, countries have seen the profound impact of education on their quality of life (Psacharopoulos & Patrinos *, 2004). With that in mind, nothing could be more transformative than providing consistent high-quality education across Cambodia's population. And these promising advancements are actually more possible than ever through the use of artificial intelligence with its adaptive algorithms. As a matter of fact, this new technology is already being used in many classrooms around the world and online to help facilitate learning through virtual and individualised educational platforms. And given how respected teachers currently are in Cambodia, improving teachers' impact has become a top priority for Cambodian leadership. After all, today's students will become tomorrow's leaders that will advance Cambodia's future.

Cambodian culture values hard work, dedication, and family – all of which make for students that are capable of many amasing accomplishments. However, given the financial, geographic, and demographic constraints, providing quality education has been a challenge. That being said, AI and its direct application to facilitate learning has the potential to transform Cambodia's education system and substantially raise the quality of life for millions of citizens.

In the future, this technology will facilitate the implementation of standardised learning in which the lessons for each student will be based on their capabilities and hard work, not on the limitations of their geographic situation. But delivering on these promises requires focused planning and execution by the leadership of Cambodia.

Currently, however, AI in education is far from the envisioned science fiction avatar that seamlessly interacts with young students. As things are now, AI remains in the nascent stages of development. Still, many scholars believe that there will be comprehensive educational applications that work directly with students. These applications will understand what each student needs, providing lessons that focus on what exactly the student must focus on to reach the next educational milestone.

Far before the previously mentioned avatar begins teaching our children, educators will be relying on AI to facilitate the traditional classroom setting. In fact, most current applications of AI in the classroom help teachers understand where students need specialised lessons or individualised training. AI is helping teachers build Smart Content, automate tutoring, grade tests, and categorise learning difficulties. This saves time for the teachers, allowing them to focus on the more substantial aspects of teaching such as lesson planning and student engagement (e.g. AI in Education) (Faggella, 2019).

Many modern examples of AI in education have emerged in countries all over the world. One notable example is China's initiative called "Education Informatisation 2.0 Digital First Education." One of the first initiatives in this program was to upgrade the curriculum by improving the availability of resources for teachers. To this end, they built a "shared resource" platform which makes teachers more productive by providing a well organised digital space for resources that have been collected from all over the country (e.g. Education Informatisation 2.0 in China: Motivation, Framework, and Vision, an exploration into Innovative Practices of Targeted Poverty Reduction Through Education using Information Technology) (Yan & Yang, 2021).

Artificial Intelligence will have a similar impact on most other industries as well. Additionally, the technology itself is an industry that will provide many opportunities for students that are capable of learning how to use these new tools. Some examples include deep learning, statistical analysis, and robotics. Cambodian students will undoubtedly have a distinct advantage in using these new technologies. This will in turn help Cambodia realise the educational promise of artificial intelligence.

5.6.6. Finance and Trade

Cambodia's GDP growth rate has been extremely stable over time and is now the sixth fastest growing economy in the world. What is unique about this growth is that it has been steady for over 20 years (See GDP Chart). The World Economic Forum has reported that only 13 economies worldwide have provided this level of stable growth. This is a sign of resilience and consistency in the country. It is also a sign that Cambodia has the discipline and drive to implement new solutions and technological innovations regularly. And artificial intelligence will be yet another solution that helps Cambodia thrive in the future (World Economic Forum, 2016).
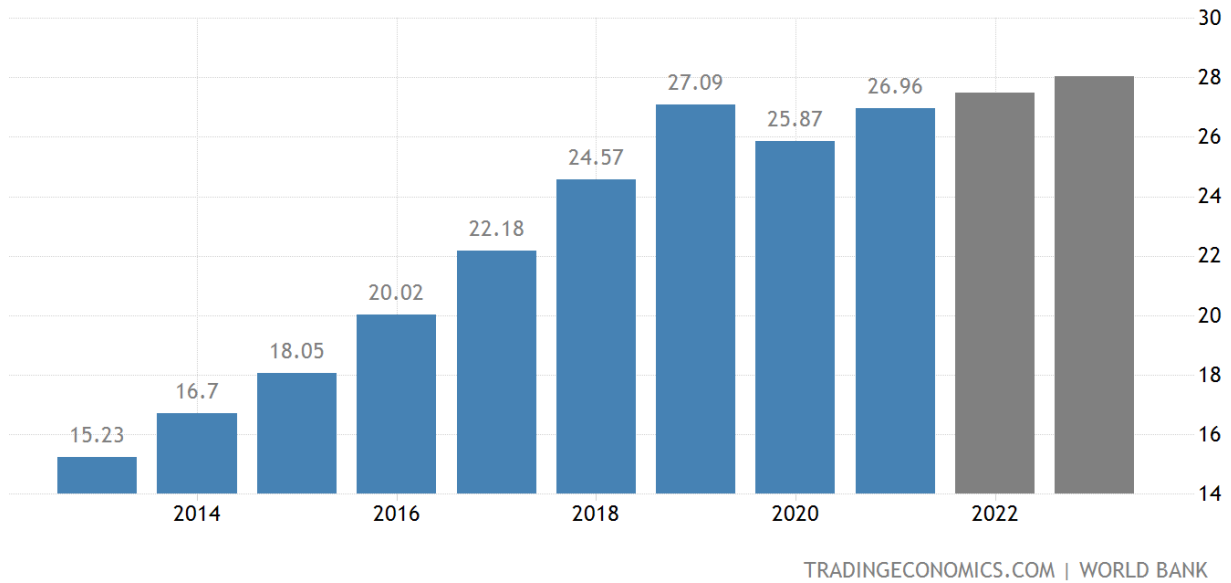
Figure 6. Cambodia's GDP capacity during last decade (World Bank, 2023)

As the economy emerges and takes off, it is imperative that its financial sector continues facilitating investment flow while domestic credits pick up. Given such opportunities, AI technology would find its place in effectively accelerating financial inclusion through its machine-learning innovations that enable more accessible and default-free credit models.
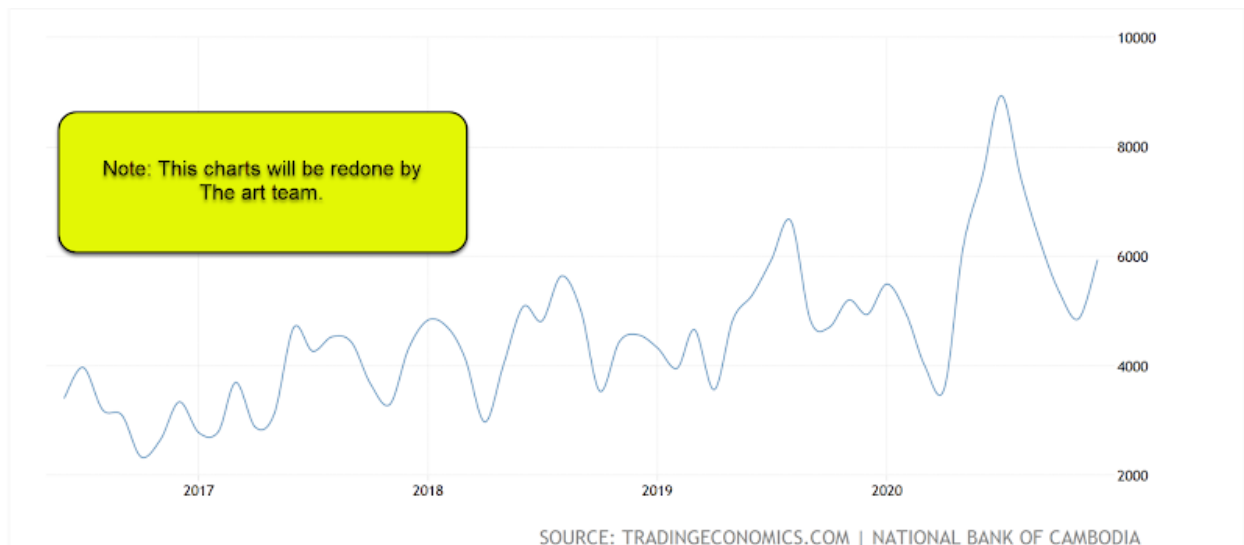
Figure 7. Cambodia's export behavior

Trade is a major reason for why Cambodia's GDP growth has had such sustained development. Improving trade is directly correlated with improving the economy in Cambodia. The better the trade, the better the economy. And artificial intelligence has much to offer when it comes to bettering trade and remaining competitive in tomorrow's international market. As the chart shows, exports are continuing to rise with apparel, footwear, and leather goods being the major drivers of growth. A continued focus on these exports and experimenting with new exports will help

Cambodia thrive in already fertile markets such as the USA, China, and Germany as shown in figure above.

AI provides many opportunities for efficiency and growth in the world market. For example, the implementation of AI for language translation in e-commerce has been shown to produce more than 17% growth in online international trade sales (Brynjolfsson et al., 2019). And there are other such examples in which AI tools are capable of managing compliance despite the numerous complexities between suppliers, clients, and shifting trade restrictions. Without AI, many industries rely on mere human intervention to constantly check for errors. However, by using AI, the system can learn how to handle these problems more efficiently and accurately, which in turn allows for a more seamless compliance operation.
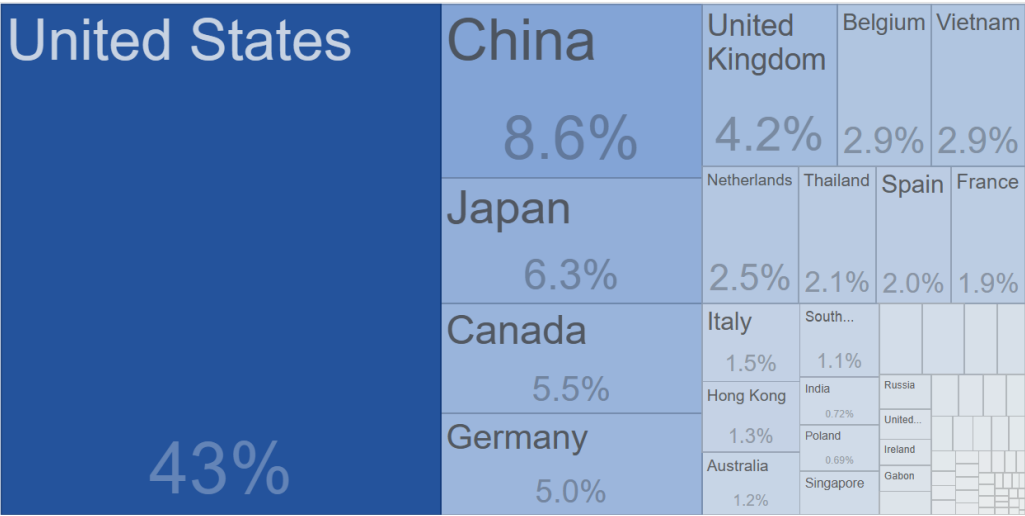

Figure 8. Cambodia export by contry

AI is also making a significant contribution by optimising the supply chain. The significant lead time required for many supply operations can derail trade operations by causing a myriad of time delays, especially when there are complex multipart orders. The ordering of one part might mean the ordering of sixty different other parts, all with different lead times. Getting ahead of these orders is key to delivering your products on time.

A similarly significant capability of this technology is the implementation of AI based smart contracts. This is where the legal contract is essentially broken down into computer code in which business rules are implemented, which then allows AI to avoid any costly mistakes while reducing manual checking. These factors all lead to easier access to trade and financing because the business investors are more confident in a process that they can measure and trust.

As more countries continue to implement AI for international trade, the compatibility of such technology across different countries would mean better communication, efficiency, and fairness in international dealings. For example, a smaller country might feel more comfortable in a deal in

which all of its factors are being considered and intentionally maximised in discussions with larger countries that have more resources. And wealthier countries will have the chance to better international relations and improve the quality of life in smaller countries with AI handling the nuances for both sides. The overall benefits of implementing AI in negotiations are that each side can move faster, have deeper confidence, and feel more comfortable with the outcomes. The key is having a system that each party can trust and that can illuminate alternatives that might have otherwise been unthought of by both sides (Höne, 2019).

This is how AI becomes sewn into the fabric of international trade. And while it does not completely replace the process or the people, it is still implemented in almost every component, delivering an improved trading operation. These improvements will be realised right to the bottom line in Cambodia, thereby driving the GDP to even higher levels (Nesbitt, 2017).

5.6.7. Healthcare and Medicine

Healthcare is one of the most important areas for the use of AI. Cambodia has already begun working with companies that utilise various levels of diagnostic technologies embedded with AI. For example, CARA has tools that help diagnose eye and cardiovascular disease in Cambodia. This is just the beginning. Artificial intelligence has the capability for use in almost every area of healthcare from diagnostics, surgery, operational efficiencies, and population disease projection analytics (Davenport & Kalakota, 2019). Future opportunities include smart hospitals where equipment and infrastructure are embedded with contact sensors that bring a hospital's architecture to a level of "ambient intelligence." These tools have provided new levels of protection for clinical professionals and safety for patients by interpreting their surroundings and gathering additional relevant data for clinicians (Standford University, 2021).

The development of such artificial intelligence in healthcare has undergone many evolutions. In the early 80s, logic systems consisting of if-then-else statements and massive rules-base engineering were defined as a type of intelligence. However, diagnostic professionals found these tools to be overwhelmingly complex and difficult to manage. One of the primary challenges was keeping the current knowledge base up-to-date, especially if the recommendation engine was providing dosage calculations. Also, rule engines typically consisted of hundreds and thousands of statements, all of which were largely error-prone and hardly classifiable in today's modern AI engines (Davenport & Kalakota, 2019). (The potential for artificial intelligence in healthcare) Most of today's AI technology is based on neural networks and deep learning. Such technology allows machines to perform tasks without specifically being programmed to do so. In this way, computers can learn from data and perform tasks in a more human-friendly way.

All kinds of problems are being efficiently handled by AI in the medical field. For instance, the massive amount of data doctors has to analyse when diagnosing a patient is typically colossal.

Health records are spread across multiple systems and do not follow any standard protocol. But AI tools bring all of the data together, then these tools analyse the structured and unstructured results to produce probabilistic diagnostics that can help the doctor quickly identify a potential illness.

In addition to diagnostics, artificial intelligence is also becoming common in treatment recommendations and avoiding medical errors. With the massive amount of data available each year, it is difficult or impossible for all clinical professionals to be up-to-date on the potential treatment regimens for uncommon diagnoses. An empirical study explaining this medical challenge has been done using modern machine-learning algorithms in the Cambodian Children's hospital (Oonsivilai et al., 2018). This study focused on the patient's antibiotic susceptibility based on patient-specific predictions. The result from the study outperformed the logistic regression models and has proved itself to be very beneficial when it comes to issuing prescriptions since it can prevent the inappropriate overuse of antibiotics, thereby reducing the patient's resistance to antibiotic treatment.

Every year more medical articles are produced than could ever be read by one person. In 2012 nearly 2 million scientific articles were published, and that trend has grown 3% every year (Chi, 2013). Furthermore, it has been well documented that patient allergy management, dangerous drug-to-drug interactions, and dealing with other complex medical conditions have yielded a risky environment for patients. But AI tools can quickly digest the latest articles and recalculate potential treatment plans almost instantaneously. This helps safeguard patients by providing clinicians with focused, uncluttered information. AI is also being used to help clinical professionals more accurately and effectively identify medical treatments with the best probability of success. For example, IBM Watson reads the patient's medical record and then determines the likelihood of a stroke, it then provides the potential success of a variety of different treatments (IBM, 2018).

Surgical robots have also been assisting clinicians for decades. But recently these robots are being embedded with AI. This is largely seen in common surgeries such as gynecologic and prostate procedures. Such technology helps the surgeon focus on more complex matters while removing much of the basic logistics of the operation (Davenport & Kalakota, 2019). Surgeons are also using AI to help keep track of all the relevant factors in their decision-making. These factors include the values and emotions of the patient, case complexity, individual judgment, and time constraints. Bringing AI tools into the surgical decision-making process helps clarify all the factors of these decisions within an objective framework. Patients thereby end up with a better outcome when both human and automated decision-making come together over their surgical procedures (Loftus et al., 2020).

5.7. Challenges

AI is currently used extensively in commercial applications like targeting advertisements, search optimisation, customer service, healthcare, transportation, and the robotic applications that have been previously explained in this article. The basic technological principles for implementing these systems have been around for decades, but the computational power and clean data necessary to implement these ideas have only recently become feasible. The most promising aspect of this implementation is supervised learning. This provides the foundation for many of the most practical examples of AI in business (McKinsey Global Institute, 2018).

However, there are many challenges and concerns that come with the use of AI. Certainly, machine learning requires massive amounts of data and computing time. Researchers are generally challenged when it comes to finding high-quality, unbiased training sets to teach AI. In many cases, hundreds of thousands, if not millions of records are required to properly implement deep learning algorithms. And data sets containing biased information can lead to undesirable results.

Most algorithms and data sets need to be tuned to the appropriate objective and all algorithms need to be tested to make sure the results are correct and appropriate. Every effort should be made for data to be stored in a usable format and be well documented so it can be appropriately applied in a learning model. Data manipulation alone is one of the most expensive and time-consuming parts of any AI project.

There are other cultural challenges to consider that branch out into new issues for leadership when it comes to incorporating AI. A cautious yet experimental mindset is necessary for this new technology enterprise to be successful. Errors are natural and even helpful for our understanding. Although sometimes the cost in time and money might increase, it should still be considered a milestone for progress. Governments and companies hoping to use AI also need to focus on innovation, critical thinking, and STEM in their educational system. External subject matter experts will certainly be able to help with data formatting and processing algorithms. However, experts who understand the underlying data and principles of how the information might be best used are in a key position to maximise the impact and profitability of this new technology (Mackinsey Global Institute, 2018).

In addition to the challenges faced by leadership, data quality, and bias, AI is also held back by computing power and infrastructure. Specifically, AI implementation is hampered by the lack of available talent and intellectually skilled practitioners, not to mention financing. In many areas funding is not available to test applications or even to provide the time to consider how these new solutions might be applied. In the short term, this research takes time and money. But in the long run, the potential benefits will far outweigh the investment (Mackinsey Global Institute, 2018).

Also, there has been much written about how AI will take jobs away from unskilled or easily automated workers. This can especially be seen in Cambodia where industries are still labor intensive (An, 2020) and have low economy-of-scale in terms of market size. This means that most of these industries would not allow Cambodian businesses to afford advanced automated and robotic machines that are made available by AI technology. This typically leads to hesitation to invest and experiment with AI. However, AI brings other opportunities, especially in the early stages of transition.   One example in education involves the potential confusion between the student and the AI program's design. The implementation of AI based learning systems in China, for example, required the hiring of hundreds of "tutors" to help students during the implementation of their lessons. And 70% of these positions were filled by women who would have otherwise gone unemployed (Xinxin et al., 2019).

The transition to AI for a country or a company will not be simple and seamless. There are and will be advances in some areas and challenges in others. The foundation of AI demands hard work in infrastructure and normal Information, as well as Communication Technology (ICT). But Cambodia has already been implementing a plan to fortify these fundamental infrastructure components (SEAN & LOR, 2020).

There have been many famous examples that show how AI can make errors and provide misleading answers during this transition. One famous example is Google's "GFE," which is short for "Google Flu Trends." It was an experimental tool that was intended to predict flu outbreaks in the United States. Initial results seemed promising, but unfortunately, it was determined that the data was unreliable in its predictions and the project was terminated. Other examples include the Microsoft Chat Bot that was making sexist and racist statements. It was shut down within 24 hours of operation. There was also the Amazon AI hiring blunder where selections that had been in use for years were clearly biased. None of these errors negate the fact that AI is a powerful technology that is here to stay. Improvements in the algorithms and data sets will undoubtedly drive positive performance in the future (Tennery & Cherelus, 2016).

Healthcare diagnostics and procedural processes with AI have also been successfully deployed. However, widespread use of AI to displace caregivers is unlikely in the short-term, and perhaps in the long term. This is because of the tremendous shortage in clinical professionals in Cambodia and around the world. Additionally, AI is seen as a diagnostic helper, but will probably never be a tool to deliver a diagnosis. Patients tend to prefer face-to-face dialogue around their diagnoses and potential treatment options. Therefore, although AI can be extremely helpful and even necessary to ease the burden of clinical diagnostics, it will not be a replacement (Davenport & Kalakota, 2019).

In many situations, the output and associated logical explanation of AI has not been made clear. For example, educational AI has been struggling to build models that allow students to learn in

steps. It has been well documented that porting curriculum content into usable AI-based frameworks is challenging and expensive. Also, identifying laddering technologies that serve to identify students' level of understanding has additional complexities. For example, a student that understands how to do addition but struggles with multiplication naturally needs specific, individualised attention in multiplication. This requires lessons to be linked in a sophisticated manner that is machine readable and integrated across curriculums.

Implementing a "knowledge tree" for such students involves an efficient network of lessons that require advanced skills, an in-depth knowledge of databases, and a solid understanding of the interplay within such systems to see how the AI model will respond to the sum total of its overall usage. Fortunately, there are many working examples of well planned and executed AI based learning engines. One example is the system implemented in China to help non-native speakers learn Mandarin. The system has an AI-based engine that engages the students and determines their level of comprehension. Then it continuously adjusts their experience to maximise understanding. Students using this system have shown significantly improved test results (Xinxin et al., 2019).

Cybersecurity and confidentiality are also major challenges for AI, particularly when the information is clinical or financially related. The implementation of AI also raises confidentiality and intellectual property (IP) issues. Training data often needs to be copied and edited for use, which may lead to a certain degree of vulnerability. With that in mind, cybersecurity should be a completely integral part of every AI project in order to properly consider the necessary protocols for safety, security, and protecting intellectual property, as well as safeguarding personal information. Regular testing and audits are required to ensure a safe and secure environment. Furthermore, proper data governance, threat detection, and legal review should be fundamental to any technological project (Oseni et al., 2021).

In Cambodia, this technology is not just about AI. It is about creating a digital framework within the existing infrastructure to implement its learning capability alongside the work of Information and Communication Technology (ICT). A relevant legal framework on data and cybersecurity is also needed to be in force to combat cybercrimes and to also provide assurance to relevant businesses, practitioners, and consumers in the field. Infrastructure is the key, and there is already a basic technological foundation that Cambodia has been building for years that will be leveraged to maximise the impact of AI in education (SEAN & LOR, 2020).

Recently, the Royal Government of Cambodia has put forth in its Cambodia Digital Economy and Society Policy Framework 2021-2035 specific measures within the short and medium term of its plan to boost investment in infrastructure and the application of AI in data governance, particularly in data use and analysis (Royal Government of Cambodia, 2021). However, to effectively use AI, an environment of experimentation and innovation is necessary. Basic

research and prototyping are required. But proper leadership and guidance for such objectives are also necessary to purposely direct this technology in a way that solves real problems for Cambodia. Many technological projects have suffered from weak leadership and misguided objectives. But constant measurement, objective evaluation, and experimenting with potential solutions are necessary in avoiding such issues.

The current reality of AI is undoubtedly promising. And the truth is that AI is already producing positive results that are used daily in business, clinical, and mechanical settings. Far from magic, the technology is math-intensive and requires highly skilled professionals for planning, implementation, assessment, and continuous monitoring/feedback to ensure appropriate results. And while the initial stages of development are error-prone, the daily use of successfully implemented AI platforms is simple and extremely reliable. Even now, AI continues to prove its worth despite the challenges of its development. But that being said, the most important key to its success is good leadership that realises the undeniable benefits AI has in store for Cambodia.

6. AI for Cambodia: Policy framework and options

Artificial Intelligence (AI) is one of the essential technologies in the world game changing in every sector to improve productivity, efficiency, and cost-effectiveness. In order to foster trustworthy AI ecosystems, it is essential for countries to develop human-centered policies that promote socio-economic and responsible AI research and development. This includes policies that encourage investment in such initiatives. These policies of AI development should take into account its national development vision as well as regional and global trends. The country's objectives, preferences, and overarching strategy for AI advancement in both immediate and distant future should be clarified. Initially, the main objective is to cultivate skilled personnel and employ AI solutions to deal with critical national focus areas that will have a swift impact on Cambodia's socio-economic status. Over time, the priority should shift to developing fundamental and advanced research, promoting high-level AI research and innovation, and establishing Cambodia's standing in advanced technology on a global scale. To reach this goal, here are some policy recommendations for Cambodia:

6.1. Define National Focus Areas

Cambodia has experienced a significant increase in internet users as part of its pursuit to become a digital nation. These users employ the internet for various reasons such as entertainment, work, and business growth. Consequently, innovative technologies like IoTs, Big data analytics, and AI are increasingly becoming prevalent in Cambodia's daily activities. To maximize this technological advancement, Cambodia should prioritize the utilization of AI in key developmental sectors. These sectors should be carefully selected to ensure that they align with the country's overall development goals. The key recommendations areas should include:

- **Service for SME:** with the rapid growth of internet users, many businesses are eager to adopt advanced technologies that can enhance customer experiences and drive business growth. One way to achieve this is by collecting and analyzing data from customers' past experiences, which can help companies deliver relevant services based on their preferences and needs. To leverage these technologies effectively, the policies should focus on key areas such as retail and e-commerce, online advertising, and customer support.

- **Manufacturing:** the growth of Cambodia's GDP has been significantly influenced by its manufacturing sector. To further enhance productivity and cost-effectiveness in manufacturing and keep up with the fourth industrial revolution, implementation of AI can help transform traditional manufacturing into advanced and smart manufacturing. This, in turn, will enable Cambodia to compete effectively in regional and global markets, leading to positive socio-economic progress. The integration of technology in manufacturing can involve real-time data collection through IoT, automation processes using robotics, and improved daily operations and decision-making through information systems and AI.

- **Mobility and Transportation:** transportation and mobility is a significant factor in stimulating economic growth, improving market accessibility, strengthening logistics supply chains, and creating new opportunities for businesses by connecting different sectors. Introducing AI to improve the efficiency and accessibility of transportation and mobility can aid Cambodia in achieving its environmental sustainability, road safety, and socio-economic objectives. To effectively implement AI in transportation, it is crucial to focus on improving transport accessibility, management and operation systems, emergency response management, security measures, and roadway maintenance and management.

- **Agriculture:** in 2018, agriculture contributed 22% to Cambodia's GDP and provided employment opportunities to around 3 million individuals. With the advancements in technology, the agricultural sector has rapidly evolved and incorporated sophisticated machinery and internet of things technology to enhance production efficiency. Given that Cambodia is primarily an agricultural-based country, the implementation of AI for enhancing agricultural productivity is imperative. The potential applications of AI in agriculture include managing production, monitoring crop growth, analyzing data and making informed decisions, detecting diseases, monitoring food quality and safety, and conducting predictive analysis.

- **Education:** providing consistent, high-quality education to its citizens will bring a significant impact on both people's lifestyles, well-being and the country's economic growth. In today's digital age, AI and other technologies have revolutionized the way we teach and learn. Despite potential challenges, these applications offer immense

benefits for transforming education. However, since technology accessibility is still limited in some regions of Cambodia due to socio-economic and geographic factors. Therefore, to maximize the profit of AI in education requires improving three main strategies: 1) improve digital infrastructure and funding to accessibility to technology for every student, 2) providing clear national policies and guidelines on the implementation of AI in teaching and learning activities, and 3) using technology to make learning contents accessible to all students regardless of their location.

- **Finance and Trade:** in order for Cambodia's economy to continue its growth trajectory, it is crucial that the financial sector keeps facilitating investment flow while also supporting domestic credits. The country's sustained development in terms of GDP growth can be attributed to trade, which plays a significant role in boosting the economy. Therefore, enhancing trade is directly linked to improving the overall economy of Cambodia. In this context, leveraging the potential of artificial intelligence can prove to be advantageous in terms of enhancing finance, trade and maintaining competitiveness in the global market of the future. AI tools can be implemented in finance and trend analysis to enhance various aspects of businesses such as international trade through automatic language translation, ensuring compliance with regulations, providing efficient customer support, creating customer profiles for targeted marketing, optimizing the supply chain management, and executing smart contracts.

- **Healthcare:** access to high-quality healthcare is crucial for the overall well-being and development of a country, and it should be a top priority in every nation's development goals. Artificial intelligence (AI) is playing an increasingly important role in healthcare worldwide, and Cambodia is already working with companies that use AI-powered diagnostic technologies. The potential applications of AI in healthcare are vast, from diagnostics and surgery to operational efficiencies and population disease projection analytics and prediction. To prevent medical errors, Cambodia should consider implementing smart hospitals where technology is integrated into equipment, infrastructure, and processes to enhance diagnosis and treatment.

- **Tourism:** Tourism is a significant contributor to Cambodia's economy, with around 11.3 million domestic and 6.61 million international tourists visiting in 2019 prior to the Covid-19 pandemic. However, in 2022, only 2.2 million international visitors were recorded, highlighting the impact of the pandemic on travel. Therefore, it has become essential to utilize technology as a means to enhance tourism activities and help the industry recover.

6.2. Develop a National AI Regulation and Guidelines

AI has the potential to bring numerous benefits to society and the economy, but it also carries significant risks and responsibilities, particularly regarding privacy, ethics, and security.

- To ensure that AI applications prioritize human-centered benefits, Cambodia must develop regulations and guidelines by a multi-ministries committee.
- The committee shall consist of the Ministry of Industry, Science, Technology & Innovation, Ministry of Post and Telecommunication and Ministry of Education, Youth and Sport.
- This new regulation and guidelines require harmonizing existing laws and creating new data protection laws that govern sensitive personal information throughout its lifecycle, from capture to storage, sharing, use, and archiving.
- To safeguard citizens' privacy, organizations of all sizes including academia should adopt a privacy-by-design approach to developing AI applications/algorithms
- The multi-ministries committee should also oversee the proper incorporation of ethics and privacy measures in AI development to ensure compliance with best practices.

6.3. Develop a National AI Infrastructure

In order for AI to be fully utilized, it is crucial to have a strong infrastructure that supports the development and implementation of AI systems. This infrastructure should be initiated by the government with the support from private industries and academia.

- This infrastructure shall be used to support students, researchers, universities, and industries in their pursuit of AI innovation.
- It shall consider various components such as hardware, software, data, and human resources that are necessary for the research and deployment of AI solutions.
- Essential components of this infrastructure may include high-performance computing systems, cloud-based platforms for data storage and processing, and open-source AI frameworks and libraries.

6.4. Promote in AI Research, Innovation, Education and Talent development

The future is expected to see the integration of emerging technologies such as big data, cloud computing, cyber security, data science, AI, robotics, 3D printing, Blockchain, and Internet of Things (IoTs) across various industries including businesses, healthcare, agriculture, and education.

- **Talent and skill development:** Cambodia faces a shortage of highly skilled workers in these areas, which highlights the need for educational reforms to equip students with modern skill sets that align with the demands of the future labor market. In addition, one of draw-back when using AI is job displacement. To tackle this challenge, the government can prioritize and support talent and skill development initiatives. These could be:

- ○ Ministry of Education, Youth and Sport shall encourage educational institutions to provide specialize course for talent and skill development
- ○ Ministry of Economics shall allocate skill development budget to support such initiatives
- ○ Companies can invest in training their workers with the necessary skills
- ○ Educational Institutions can play the role of trainer to provide necessary training to companies
- **Developing AI Research Culture:** for sustainable benefits and human capital development, Cambodia should also encourage AI research and innovation activities. This may include:
  - ○ Ministry of Education, Youth and Sport shall provide incentives and fund for AI research and innovation
  - ○ This incentive and fund shall be classified into 3 categories:
    - Research fundamental: to support initiatives of researchers and academia
    - Innovation research: to support applied research that are potential for commercialization. This research shall be the cooperation between educational institutions and industries
    - Flagship project: to support long-term and impactful research projects. This kind of project shall consist of educational institutions, industrial and international organizations.

6.5. Develop AI Ecosystem

To achieve sustainable and inclusive growth, Cambodia's development strategy should prioritize investing more in AI research, innovation, and entrepreneurship. This can be accomplished by:

- Creating an AI ecosystem that fosters collaboration beyond just cooperation among stakeholders.
- Use the quadruple helix paradigm to involves academics, government, industrial and societies to ensure social equality, minimize perpetuate biases and pose privacy risks
- Develop a national strategy to encourage business collaboration. This may include:
  - ○ The Ministry of Economic shall consider funding budgets to support public-private partnerships research & innovation, knowledge transfer and commercialization on applied-AI projects.
  - ○ Governments should also consider policies such as tax reductions or incentives for industries investing in AI research and innovation.
  - ○ Such policies will encourage industry to invest in research and development, build innovative applications, and generate job opportunities

○ Encourage collaboration between industry and educational institutions. Academia can contribute research expertise, train talent, and facilitate knowledge transfer to industry

6.6. Foster International Collaborations

Global collaboration and swift policy actions are essential in the market-driven field of AI. For Cambodia to remain competitive on the global stage, it is crucial to cultivate world-class talent through various strategies.

- The first step is to identify skill gaps in education, research, and innovation. Then, offer attractive scholarships and incentives for Cambodian individuals to study abroad and fill these gaps. The scholarship source can be funding by
  ○ Government through budget planning organized by Ministry of Education, Youth and Sport
  ○ Industry funding
  ○ International cooperation and co-funding
- Secondly, Cambodia needs to establish its own research platform to facilitate knowledge sharing and promote research activities amongst Cambodian researchers, ultimately improving the quality of research in the country and creating opportunities for international partnerships.
- Lastly, implementing a special grant package that encourages regional and international collaboration will help to advance AI research and innovation in Cambodia and elevate Cambodia's research quality to an international level.

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