TECHNOLOGY FOR DEVELOPMENT

Indo-Pacific State of Play

JANUARY 2018

By the Institute of Development Studies
and Caribou Digital

Commissioned by innovationXchange,
Department of Foreign Affairs and Trade

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Executive Summary

Innovative uses of technology, entrepreneurial activities and the digital upskilling of workforces have seen economies transform. Australia's International Cyber Engagement Strategy highlights the importance of digital technologies to accelerate sustainable development and inclusive economic growth and sets goals for Australia's work in the Indo-Pacific to harness the benefits of technology.

The Indo-Pacific region is diverse, containing some of the most digitally engaged countries in the world as well as countries with unique geographic challenges impeding their ability to advance technologically. Groups within countries also have diverse experiences with technology, reflecting global digital divides including gender, age, education, ability, income, ethnicity and other marginalised groups.

To assist in understanding the technology for development state of play across the region, countries are divided into three categories based on their economic and technological positions – **Scale Leaders**, **Fast Developers** and **Isolated Islands**.

Scale Leaders such as Indonesia, Philippines and Vietnam have developed significantly over the past two decades with national information communication and technology strategies that are now maturing. Fast Developers such as Myanmar, Nepal and Sri Lanka have grown a strong level of connectivity by leap-frogging fixed line Internet and benefiting from the relatively cheaper costs of deploying mobile networks. Isolated Islands such as Kiribati, Tonga and Vanuatu have limited sea-cable access, and rely more on satellite connectivity, and suffer from the increased expense and lower bandwidth of this technology.

Across the Indo-Pacific, digital technologies have allowed humanitarian and development interventions to scale to larger populations with lower costs and to create the enabling environment for innovation in sectors such as education, health, agriculture, economic development and women's empowerment. These interventions are enabled by the essential digital building blocks that forge a digital economy and society – **Internet connectivity**, **digital financial services** and **digital identity**.

The Indo-Pacific is home to countries with some of the highest and fastest rates of connectivity in the world, as well as some of the least connected countries where Internet penetration is low. Barriers to internet adoption in the Indo-Pacific region can include a lack of locally relevant content, affordability, digital literacy, accessibility to people with a disability and social and cultural barriers impacting access for women and other marginalised groups.

Digital financial services are important to advancing financial inclusion more broadly, as digitising services can help address barriers to financial inclusion. A digital identity helps to capitalise on the benefits of digital technologies—many governments and businesses require some form of identity to access their services, and this is replicated when services are offered online.

Emerging technologies are starting to have impact in the development sector. These technologies are exciting and have the potential to rapidly address large-scale economic, social or political challenges. They include both software innovations, such as big and open data initiatives, new platforms based on blockchain technology, and the application of artificial intelligence and machine learning, and hardware innovations such as Internet of Things enabled devices and smart city transformations.

The regional overview presents opportunities for action in order to optimise the use of technology for development outcomes in the Indo-Pacific region. These include approaches to: stimulate innovation in development-enabling technologies, enhance inclusion through inclusive programming and improved infrastructure, increase efficiencies through catalytic investment in capacities, and support a free, open and secure Internet.

Introduction

Digital technologies, when considered and applied with an inclusive lens, have the potential to be profound enablers of sustainable development and economic growth. The spread of the Internet and digital technologies has facilitated greater connectivity, reducing physical and functional barriers between people, businesses and governments.

Australia's first **International Cyber Engagement Strategy** lays out three simple yet ambitious goals to harness the opportunities of the digital age and accelerate sustainable development in the Indo-Pacific:

- **Improve** connectivity and access to the Internet across the Indo-Pacific, in collaboration with international organisations, regional governments and the private sector.
- **Encourage** the use of resilient development-enabling technologies for e-governance and the digital delivery of services.
- **Support** entrepreneurship, digital skills and integration into the global marketplace.[1]

Accelerating sustainable development requires a much deeper and more strategic use of technology than simply improving the efficiency of old processes through higher-tech modes of delivery. Rather, innovation in the methodology itself is essential to access the promised 'digital dividends' of connectivity.[2]

Digital divides exist within and between countries globally, and in the Indo-Pacific. The International Cyber Engagement Strategy commits Australia to work bilaterally, regionally and multilaterally to bridge these divides in the Indo-Pacific. Achieving development outcomes for all requires an inclusive approach that analyses and integrates the particular needs of people whose access is limited, such as women and girls, older persons, people with disabilities, indigenous, ethnic and religious minorities, rural populations and the poor. It requires an approach that recognises and offsets the risk that technology can compound gender and other inequalities, and the safety of women and vulnerable groups.

The Department of Foreign Affairs and Trade's innovationXchange commissioned this paper to inform the operationalisation of the Technology for Development chapter of Australia's International Cyber Engagement Strategy. This paper assesses the state of play of development-enabling technologies in the Indo-Pacific, with the aim of informing development actors who may be less familiar with foundational and frontier technologies, their potential benefits, and how to leverage them. It was developed in consultation across the Department of Foreign Affairs and Trade, and with leading experts in the private sector, academia, civil society and other donor agencies. Ultimately, however, the views in this paper reflect the views of the organisations that authored it.

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1 DFAT 2017, *Australia's International Cyber Engagement Strategy*, http://dfat.gov.au/international-relations/themes/cyber-affairs/aices/chapters/part_7_technology_for_development.html, viewed on 27 December 2017.

2 World Bank Group 2016, *World Development Report 2016: Digital Dividends*, World Bank, Washington.

Section 1 presents an analysis of the current landscape of digital adoption in the Indo-Pacific region, making comparisons with other regions for context. It provides a framework for segmenting the region in terms of digital adoption. It highlights countries with the infrastructure and systems for success and where unique geographical and political challenges will require specific kinds of innovation to achieve the benefit of the digital dividends for all.

Section 2 introduces the key digital building blocks that forge a digital economy and society – Internet connectivity, digital identity and digital payments. It discusses how and where they are reaching scale, what impact they are having in helping countries achieve their development objectives by sector, where donor programs are supporting their deployment, and how they can provide the enabling environment for other digital innovations in sectors such as education, health, economic empowerment, agriculture and nutrition, energy and water access.

Section 3 discusses innovations at an earlier stage of impact that have the potential to accelerate achievement of the Sustainable Development Goals (SDGs) but require digital building blocks to be in place before evolving, such as the Internet of Things, blockchain, artificial intelligence and machine learning.

Section 4 suggests a number of possible opportunities to optimise the use of technology for development to achieve development outcomes in the Indo-Pacific.

1 – Regional overview

1.1 Indo-Pacific – a region of complexity, challenges and opportunities for technology innovation

The Indo-Pacific region is diverse, containing some of the most digitally engaged countries in the world as well as countries with challenges unique to their geographic placement, such as Pacific Island states. Indo-Pacific countries bordering the South China Sea towards the lower archipelago states have benefited from their proximity to digital technology leaders such as China, South Korea and Japan and their well-developed and resourced hardware and software industries.

These countries are well served from the density of fibre optic cables that hug the coastline near the mainland. Even those who have only recently begun to implement digital technology are able to scale adoption quickly because of beneficial conditions. Myanmar was a late adopter of mobile technology, with major mobile operators only building out their networks within the past five years, but already the country has a mobile phone adoption rate of over fifty per cent. As a result it has leapfrogged directly to a smartphone-based Internet world.

Island states lose the advantage that proximity to major fibre optic cable routes provides, and many countries in the Pacific lack fast, affordable connectivity. This does not mean that they are not innovative, or in some instances leading the world. The Philippines is a global leader in outsourced digital microwork, and in supporting challengers to the fibre optic market – such as satellite and other aerial Internet connectivity products. Will these regions leapfrog fibre, becoming the pioneers of new satellite-based connectivity? The private-sector space race between companies such as SpaceX and Blue Origin is reducing the price to deploy satellites almost daily, which suggests there is a lot of innovation that will potentially benefit these island nations.

Inequality of access to digital technology, both between and within countries, is a key factor in the regional state of play. Digital divides exist along gender, age, ethnicity, education, ability, income and other lines, meaning digital dividends are not enjoyed equally.

In addition to its diversity, the Indo-Pacific region is evolving rapidly in its access to technology. Since 2015, Southeast Asia has added over 70 million new internet users, and in 2017 had 330 million active internet users.[3] The Australian Government is currently working with the governments of Papua New Guinea (PNG) and Solomon Islands on a project to lay a new undersea high speed telecommunications cable from Australia to Port Moresby and Honiara. This will substantially improve international telecommunications and Internet access, providing significant economic and development benefits to both countries, including for government services in education and healthcare. This infrastructure will also provide the people of PNG and Solomon Islands more reliable

[3] Anandan, R, Sipahimalani, R, Saini, S, Bharadwaj, A, Beattie, R, Kim, D & Aryasomayajula, S 2017, *e-Conomy SEA Spotlight 2017: Unprecedented growth for Southeast Asia's $50B internet economy*, https://apac.thinkwithgoogle.com/intl/en/research-studies/e-conomy-sea-spotlight-2017-unprecedented-growth-southeast-asia-50-billion-internet-economy.html, viewed on 27 December 2017.

connectivity, greater levels of accessibility and improved data prices for consumers.

This regional diversity could present considerable opportunities for taking a creative and experimental approach to digital development efforts across the region. Flexible donor funding can enable an R&D-based approach of experimentation and risk taking, documenting and sharing lessons to scale successful approaches. Such experimentation is widely seen as being integral to effective approaches for dealing with complex, diverse development challenges such as those found across the region.

MAPPING THE VARIETY OF TECHNOLOGY DEVELOPMENT WITHIN THE REGION

The Indo-Pacific region encompasses some of the most and least developed countries in respect of digital capacity and development. It is difficult to categorise them collectively in order to present a single strategy that works for the entire region. But by examining the current state of the digital economies and societies within the regions, it is possible to identify countries that share similarities in their growth, challenges and opportunities.

Figure 1 plots World Bank gross domestic product (GDP) per capita data for select Indo-Pacific countries[4] against data from the Groupe Speciale Mobile Association (GSMA) [5] on mobile subscriptions as a percentage of population[6], which allows the region to be divided into three segments in relation to economic output and adoption of technology (Table 1).

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[4] World Bank (2017), *GDP per capita (current US$)*, https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2016&start=2016&view=map, viewed on 1 January 2018.

[5] GSMA is a trade association which represents the interests of mobile operators worldwide, including nearly 800 operators and 300 companies in the mobile ecosystem. It also produces industry-leading data analysis and events.

[6] GSMA Intelligence 2017, Definitive data and analysis for the mobile industry, https://www.gsmaintelligence.com, viewed on 27 December 2017.

Figure 1: World Bank GDP per capita (2016) versus GSMA mobile subscription for select Indo-Pacific countries.

Source: GSMA Intelligence 2017, *Definitive data and analysis for the mobile industry*, https://www.gsmaintelligence.com and World Bank (2017), *GDP per capita (current US$)*, https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2016&start=2016&view=map.

Table 1: Division of select Indo-Pacific countries into three segments based on economic output and adoption of technology.

Segment	Countries
Scale Leaders: Countries that have developed significantly over the past two decades with national information communication and technology (ICT) strategies that are now maturing.	Indonesia, Philippines, Vietnam, Cambodia, Fiji, Mongolia
Fast Developers: Countries that have grown a strong level of connectivity despite being latecomers by leap-frogging fixed line Internet and benefiting from the relatively cheaper costs of deploying mobile networks.	Sri Lanka, Bhutan, Nepal, Myanmar, Pakistan, Bangladesh
Isolated Islands: Countries that have limited sea-cable access, and rely more on satellite connectivity, and who suffer from increased expense and lower bandwidth of this technology, or who have very low income populations and challenging social and political working environments.	Samoa, Tonga, Marshall Islands, Vanuatu, Laos, Solomon Islands, Papua New Guinea, Timor-Leste, Micronesia, Kiribati, Afghanistan

1.2 Scale Leaders

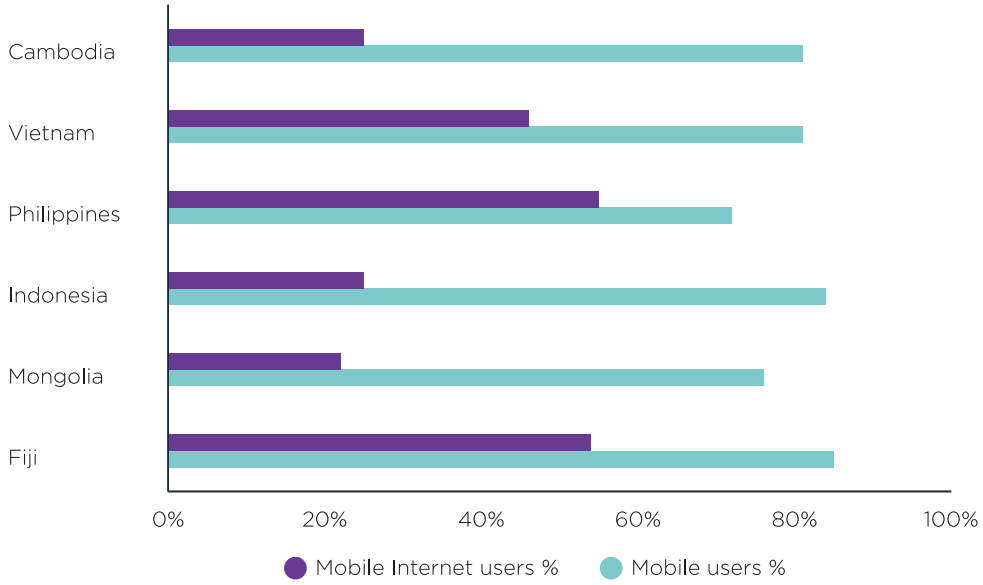
CHARACTERISTICS

Countries with advanced technology industries, high levels of connectivity and digital service adoption, and generally higher GDP. These countries provide case studies that can be beacons for the region, whilst also sometimes showing the problems that can develop alongside the wide-scale adoption of technology. Least in need of core infrastructural support, these countries can be learning partners for other nations in the region and may benefit from support for civil society and governance as they grapple with the challenges of a digital society and economy.

LEVEL OF CONNECTIVITY

In these regions mobile adoption is very high, typically with more than two thirds of the population having access to and using mobile phones, predominantly smartphones. As a consequence, mobile Internet penetration is also relatively high, often reaching more than 50 per cent of population.

Figure 2: Type and level of connectivity for Scale Leaders in the Indo-Pacific region.



Source: GSMA Intelligence 2017, *Definitive data and analysis for the mobile industry*, https://www.gsmaintelligence.com.

EXAMPLE OF INNOVATION

A stand-out example among Scale Leaders is Vietnam, a country that has developed a strong information and communication technology (ICT) industry in both hardware and software. Largely as a consequence of its history of significant levels of outsourced ICT services, including for major companies such as Microsoft and Samsung, Vietnam has built a population of experienced software developers and is significantly advanced in terms of mobile app developers.[7] This base of over 70,000 people working in software will likely pay dividends in Vietnam's ability to leverage new digital technologies. The Government is focused on further strengthening the sector. It has developed a Master Plan for Information Technology,[8] and is in the process of creating a more business friendly environment, including through regulatory reform, with an emphasis on promoting start-ups as a new driver for economic growth.

[7] Caribou Digital 2016, Winners and Losers in the Global App Economy, http://cariboudigital.net/winners-and-losers-in-the-global-app-economy/ and Australian Trade and Investment Commission, *Export markets – Vietnam*, https://www.austrade.gov.au/Australian/Export/Export-markets/Countries/Vietnam/Industries/ICT, viewed on 27 December 2017.

[8] https://www.austrade.gov.au/Australian/Export/Export-markets/Countries/Vietnam/Industries/ICT, viewed on 27 December 2017.

1.3 Fast Developers

CHARACTERISTICS

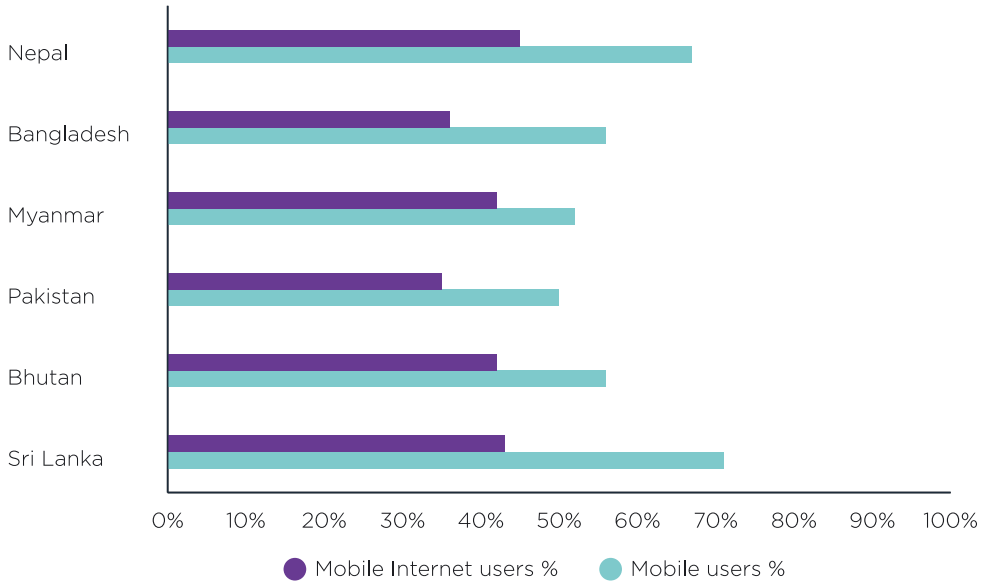
Often large and populous nations, but with lower GDP and corresponding large lower-income populations, these countries have benefited as the cost of technology access has tumbled in the past decade. Many of these countries pioneered new business models that have made technology accessible and affordable to lower-income users. These countries can benefit most from programs that support innovation in business model and service delivery, helping scale down innovation to reach large populations of low-income and other under-serviced users. A tangible opportunity in these countries is investment in local and national innovation actors, especially in civil society and those supporting the inclusion of women and marginalised groups.

An expert consulted for this document predicts that "technology for development breakthroughs are going to come from local and national NGOs. [They] understand the local political, social and development context. And they have often being trying to solve these problems for a long time."

LEVEL OF CONNECTIVITY

Mobile internet and Mobile penetration hover around 50 per cent across these countries, with surprisingly high levels of Internet adoption driven by the scale economics of population size further reducing pricing through competition – meaning cheaper handsets and cheaper data for customers.

Figure 3: Type and level of connectivity for Fast Developers in the Indo-Pacific region.



Source: GSMA Intelligence 2017, *Definitive data and analysis for the mobile industry*, https://www.gsmaintelligence.com.

EXAMPLE OF INNOVATION

Bangladesh, as a scale market for services aimed at lower-income users, has subsequently become a leader in terms of mobile business models aimed at the poor. Grameen's Village Phone program pioneered the shared-usage model of mobile phone distribution that brought availability and affordability of mobile services to the very poorest rural users,[9] and bKash has become the fastest growing mobile money service globally after Kenya's MPesa.[10]

1.4 Isolated Islands

CHARACTERISTICS

Often geographically isolated in the Pacific, these countries have struggled to get affordable, fast connectivity via fibre optic undersea cabling, and therefore have fallen behind the curve in terms of digital connectivity and adoption. Some countries have experienced economic and political instability which has slowed technological development. However, the potential for new aerial modes of connectivity – discussed in detail in section two – could radically alter these countries by creating a more level playing field in terms of Internet accessibility and affordability. The relatively low levels of investment in traditional fibre and mobile connectivity provide clear opportunities for innovative new companies to enter these markets. These markets will benefit most from core infrastructure programs that meet this need.

There is clear opportunity to help bridge the technological and institutional aspects of development. For example, one expert consulted for this paper described how the Australian government had been able to help design a responsive sector-wide approach to education in the Solomon Islands using SMS in the wake of the deregulation of the telecommunications sector:

"Having technology and data to talk to government [about the issues they face] is extremely useful. The question is then: how can we expand that into other areas in which the government works?"

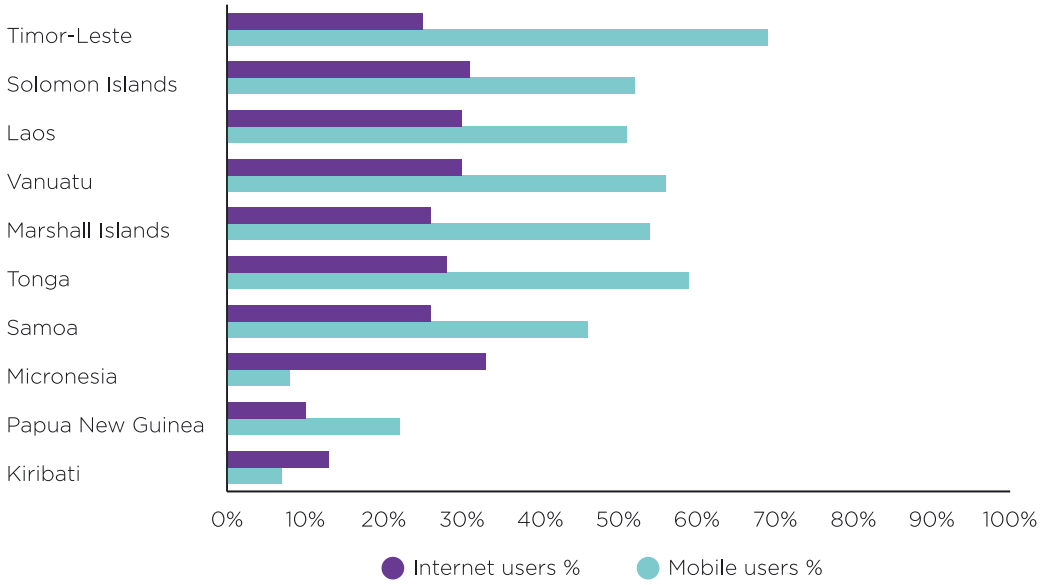
LEVEL OF CONNECTIVITY

Connectivity has a very poor reach in these regions, mainly for geographic reasons, and therefore mobile penetration for basic 2G voice and text is often around 50%, but Internet penetration falls far behind as speeds are slow, availability is patchy, and costs are high as there is little competition from multiple service providers.

[9] Grameen Telecom 2016, *About Village Phone Program,* http://www.grameentelecom.net.bd/about-village-phone.html, viewed on 27 December 2017.

[10] BRAC Bank (2017), bKash, https://www.bkash.com/, viewed on 27 December 2017.

Figure 4: Type and level of connectivity for Isolated Islands in the Indo-Pacific region.



Source: GSMA Intelligence 2017, *Definitive data and analysis for the mobile industry*, https://www.gsmaintelligence.com.

EXAMPLE OF INNOVATION

Using digital methods, the DFAT-funded Tupaia program is mapping health and clinic usage data across the Pacific Island region.[11] Using global positioning system technology, local pharmacists can log the condition and usage of clinics, and open-source software mSupply Mobile provides an interface to monitor their stocks of medicines. Combined, these technological innovations help cut waste, increase medicine availability and allowing local users to prevent wasted trips to closed or stock-out clinics.

[11] Tupaia 2017, Tupaia: Health resource and supply chain mapping for the Asia Pacific region, https://beta.tupaia.org/, viewed on 27 December 2017.

CASE STUDY

China's impact on the region

Over the past decade, China's manufacturing hubs have had significant impact in reducing the price of a wide range of technology hardware – from mobile handsets to solar panels. The same period has also seen colossal growth in domestic software service companies in China, where the complex regulatory environment for international firms has effectively locked out international competition. This, when combined with a rapidly growing middle class and the scale economics of delivering technology to a market of over a billion consumers, has seen the emergence of large digital services companies such as Alibaba and TenCent.[12]

[12] Chandley, C 2017, 'Tencent and Alibaba Are Engaged in a Massive Battle in China', in *Fortune*, http://fortune.com/2017/05/13/tencent-alibaba-china/, viewed on 27 December 2017.

Alibaba has grown an ecommerce and payment empire, driving one of the largest initial public offerings on the New York Stock Exchange in recent years. TenCent launched their WeChat messenger service in 2011, and it already claims around 890 million daily users and its own payment infrastructure. The consequence of these two companies locked in competition in such a huge market has been called a "golden age of financial inclusion in China", with digital financial services reaching near 100 per cent of the population, and driving a reduction in the use of cash in many of China's cities.[13]

China's mobile payments market is now worth US$5.5 trillion annually, almost 50 times larger than the United States market of US$112 billion.[14] While this phenomenal growth comes from within China, as Chinese digital service companies look beyond their borders for continued growth, it will have impact in the Indo-Pacific region. As these services mature and provide important digital financial service innovation in new markets, their impact on sustainable development in the Indo-Pacific will depend on ensuring access to the Internet remains open to all, and regulators strike an appropriate balance between convenience and consumer protection.

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13 Porteous, D 2016, 'Is it China's Golden Age in Digital Financial Inclusion?' in *fibr*, https://blog.fibrproject.org/is-it-chinas-golden-age-in-digital-financial-inclusion-85ad7c6ed9d0, viewed on 27 December 2017.

14 Mozur, P 2017, 'In Urban China, Cash is Rapidly Becoming Obsolete', in *The New York Times*, https://www.nytimes.com/2017/07/16/business/china-cash-smartphone-payments.html, viewed on 27 December 2017.

1.5 Digital divides within countries

Reflecting global trends, access to digital technology and its dividends within countries in the Indo-Pacific is not equal. The above analysis at country level segmenting the region into Scale Leaders, Fast Developers and Isolated Islands obscures the differential experience of technology by groups within countries. Men, women, people with disability, older persons, indigenous, ethnic and religious minorities, people on lower incomes and other marginalised groups often have different access to technology. Figure 5 illustrates this point with an example of the substantial differences in mobile internet usage in three Indo-Pacific countries by gender, income, rural/urban location, and literacy levels.

Figure 5: Percentage of the adult population using mobile Internet during a 90-day period in 2016, Bangladesh, India and Pakistan.

Source: Croxson, H & Towntree, O 2017, *Triggering mobile internet use among men and women in South Asia*, GSMA, p. 12.

In order to deliver inclusive development outcomes with technology, implementers must develop approaches that not only count access and use of technology by women and other groups, but further unpacks the different risks and opportunities, and the extent to which technology is compounding gender and other inequalities, or disrupting it. To be inclusive, technology responses should avoid reinforcing unequal power relations.

2 – Essential Digital Building Blocks for Sustainable Development

Across all sectors we have seen how digital channels have allowed humanitarian and development interventions to scale to larger populations with lower costs. In Table 2 we explore examples of how technology has brought great benefit to various development sectors.

However, for any of these potential interventions to take place there are certain technologies that act as essential building blocks – providing key services in themselves and combining to provide the basis for further innovation. These are:

- **Internet Connectivity:** Access to the Internet over different networks and devices.
- **Digital Financial Services:** Overcoming the lack of physical banking infrastructure with mobile phone and digital banking.
- **Digital Identity:** Creating and managing a digital identity for the user, for authentication for services such as social payments or banking, and for legal statehood as in birth registration.

Table 2: Examples of digital humanitarian and development interventions in the Indo-Pacific region.

Sector	Example interventions
Health	In the Philippines, mClinica works with pharmacies to collect health data from free tools for stock management and prescriptions. This data has provided the evidence for significant improvements in health outcomes through better understanding of clinic and patient activities.[15]
	Mobile Obstetrics Monitoring (MOM) is a smartphone app solution, developed by Philips, and designed for care providers to help reduce maternal mortality rates through early monitoring and risk stratification. In a year-long pilot in 2016 in collaboration with the Bunda Medical Centre in Padang, Indonesia, MOM delivered positive results including a threefold increase in the early detection of high risk pregnancies. About 1,500 mothers were benefiting from the solution as of January 2017.[16]

[15] mClinica, *Connecting Pharmacies. Transforming Global Health*, http://www.mclinica.com, viewed on 27 December 2017.
[16] GSMA 2017, *Scaling digital health in developing markets*, https://www.gsma.com/mobilefordevelopment/programme/mhealth/scaling-digital-health-in-developing-markets, viewed on 27 December 2017.

Sector	Example interventions
Agriculture	In Pakistan, mobile operator Telenor launched Khushaal Zamindar – meaning 'Prosperous Landlord' – an agricultural valued-added service targeting small scale farmers using interactive voice response and SMS. Telenor provides location-specific weather forecasts along with contextual agronomic advisory information and tips for livestock management. The service has reached more than 3 million customers, 66 per cent of them living below the poverty line.[17]
	In Papua New Guinea, Market Development Facility has partnered with MiBank to support more farmers to access its banking services, as well as buyers, processors and exporters to use the mobile money service MiCash to pay their suppliers – this provides better, more reliable access to money from sales. In PNG, as 75 per cent of the population is unbanked, such services can help farmers to better save money and access formal financial products.[18]
Governance	Mzalendo is a mobile website that aims to provide better information on Kenyan Members of Parliament (MPs) than is available on official government websites, including the ability to rate MPs based on their effectiveness serving their voters. The service was built on open-source software offered by MySociety, an open governance technology non-profit based in the United Kingdom, who have also launched similar platforms in Nigeria and many other emerging markets.[19]
Economic Development	Digital work – whether software development or microwork – is the most obvious and measurable form of economic development driven by digital innovation. Samasource is one example, which hires, trains and employs people living in poverty to deliver digital work remotely.[20] Rockefeller Foundation in 2013 released a landmark report on digital work, mapping the movement from basic outsourced information technology (IT) work through to full digital entrepreneurship. Though the value creation of the supposed Silicon Savannah in East Africa has yet to materialise fully, there is real potential for economic development in the connectivity of digital networks across remote communities. The World Bank's Pacific Possible report identifies outsourced digital work, and online outsourcing – or digital microwork – as an opportunity for the Pacific Islands.[21]
	In 2018 Dialog Axiata will be rolling out a digital payment platform across 200 villages in the Northern Provinces of Sri Lanka. Customers will benefit by gaining access to modern financial services including savings, loans and digital payment mechanisms. By working with retailers, Dialog will support the creation of a cohort of around 200 digital entrepreneurs.[22]

[17] Palmer, T & Darabian, N 2017, *Khushaal Zamindar: A mobile agriculture service by Telenor Pakistan,* GSMA, London.
[18] MDF 2017, *Papua New Guinea's Rural Farmers Connected to Essential Banking Services*, https://mdf.exposure.co/papua-new-guineas-rural-farmers-connected-to-essential-banking-services, viewed on 27 December 2017.
[19] Nixon, M 2016, 'Mzalendo: more reliable than the Kenyan government's website', in *MySociety*, https://www.mysociety.org/2016/02/25/mzalendo-more-reliable-than-the-kenyan-governments-website, viewed on 27 December 2017.
[20] Samasource 2018, Impact Sourcing, https://www.samasource.org/model, viewed on 5 January 2018.
[21] Faith, B, Hernandez, K & Ramalingam, B 2017, *Digital Development Summit 2017, The Future of Work: Background Paper*, Institute of Development Studies and World Bank 2017, *Pacific Possible: Long-term Economic Opportunities and Challenges for Pacific Island Countries*, World Bank, Washington.
[22] DFAT 2017, *Digital payment platform in North Sri Lanka*, http://dfat.gov.au/aid/who-we-work-with/private-sector-partnerships/bpp/Pages/sri-lanka-north-digital-payment-platform.aspx, viewed on 27 December 2017.

Sector	Example interventions
Energy	MiBank, in partnership with solar provider Empawa, is piloting Pay-As-You-Go (PAYG) solar loan product in PNG with support from the Pacific Financial Inclusion Program. At the same time as providing an affordable means to accessing electricity, the PAYG model provides a new channel that financial services providers can harness to reach underserved consumers.[23]
	Village Infrastructure Angels deliver solar-powered mills and innovative pay-as-you-go home power stations to rural villages across Vanuatu. Solar-powered mills reduce the time needed to process food and eliminate the need to travel long distances to access agro-processing facilities. These assets are leased to villagers for one to five years with ownership transferring at the end of the lease period.[24]
Education	Andela is an innovative company training sub-Saharan African software developers, and then sourcing work for them on a consultancy basis from Western companies. Andela has received funding from many US venture capital firms as well as the Chan-Zuckerberg Foundation, and has grown considerably with cohorts in Kenya and Nigeria. In South East Asia, Wizeline provides similar outsourced programming services, with an office in Vietnam.[25] More information on the use of technology in education can be found on the World Bank's EduTech blog.[26]
	Ruangguru in Indonesia has developed a freemium learning management system that helps students prepare for exams using content tailored to the national curriculum, helps teachers to crowdsource educational content and distribute it to students. Their online marketplace for private tutoring has more than 27,000 teachers supporting more than 100 subjects. Ruangguru is a winner of the MIT Solve Youth, Skills & the Workforce of the Future challenge.[27]

[23] Pacific Financial Inclusion Programme 2016, *Solar power drives financial inclusion: MiBank pilots affordable solar loans platform in Papua New Guinea*, http://www.pfip.org/newsroom/press-releases/2016-2/solar-power-drives-financial-inclusion-mibank-pilots-affordable-solar-loans-platform-papua-new-guinea, viewed on 27 December 2017.

[24] DFAT 2017, *Improving productivity with solar agricultural mills in Vanuatu*, http://dfat.gov.au/aid/who-we-work-with/private-sector-partnerships/bpp/Pages/vanuatu-improve-productivity-solar-agricultural-mills.aspx, viewed on 27 December 2017.

[25] Shieber, J 2017, 'Wizeline expands its outsourced IT services business into southeast Asia', in *TechCrunch*, https://techcrunch.com/2017/12/13/wizeline-expands-its-outsourced-it-services-business-into-southeast-asia, viewed on 27 December 2017.

[26] World Bank 2016, *mEducation Alliance*, http://blogs.worldbank.org/edutech/category/tags/meducation-alliance, viewed on 27 December 2017.

[27] Ruangguru 2017, *Ruangguru Digital Bootcamp*, https://solve.mit.edu/challenges/youth-skills-the-workforce-of-the-future/solutions/2359, viewed on 27 December 2017.

Sector	Example interventions
Resilience Disaster Response	Displaced people are increasingly connected, living in places covered by mobile networks and with mobile phone ownership rates that rival those of the world's overall population. As humanitarian agencies look for improved efficiency, accountability and increased effectiveness of service delivery, they are increasingly prioritising the use of cash and digital financial services over in-kind assistance. Through their Building Blocks program, the World Food Program (WFP) has piloted the use of blockchain to replace the payment part with a ledger that records the transactions on a private blockchain.[28]
	With increased access to mobile devices – ranging from low-end to smartphones – and access to mobile internet and social media channels, mobile technologies can become a game changing tool to enhance humanitarian service delivery and programmatic remote monitoring. The GSMA Disaster Response Program works with mobile operators, humanitarian organisations and governments to improve network preparedness and restoration, providing more effective, coordinated support to humanitarian responders and disaster affected populations.[29]
	BIMA in PNG provides affordable life and hospitalisation insurance cover via a mobile platform to low-income, financially underserved Papuans. In the region, they have operations in PNG and Fiji and estimate that 80 per cent of their customers gain access to insurance for the first time.[30]

[28] Wong, JI 2017, 'The UN is using ethereum's technology to fund food for thousands of refugees', in *Quartz*, https://qz.com/1118743/world-food-programmes-ethereum-based-blockchain-for-syrian-refugees-in-jordan, viewed on 27 December 2017.

[29] GSMA 2017, *Disaster Response Programme*, https://www.gsma.com/mobilefordevelopment/programmes/disaster-response, viewed on 27 December 2017.

[30] InnovationXchange 2015, *BIMA Leapfrog: Mobile SME Insurance in the Pacific Islands,* http://pacifichumanitarianchallenge.org/winners/#BIMALeapfrog, viewed on 27 December 2017.

Sector	Example interventions
Gender Equality and Advancement	When done in an inclusive way, mobile phones and technology can provide opportunities that empower and enable women, often by circumnavigating power architectures in families and society. Programs such as GSMA's Connected Women seek to increase the number of women using technology, whilst being aware of how digital culture can often be a difficult environment for women around the world to safely have a voice.[31]
	The approach of Bangladesh-based non-government organisation BRAC is to empower women and individuals who live in disadvantaged positions. In 2015, the program sought to digitise this process through a pilot project, *Sanitation Loan through Mobile Money,* which was carried out in the Northern part of Bangladesh. BRAC's Water, Sanitation and Hygiene (WASH) program staff conducted regular training sessions through which 350 women learnt how to operate mobile phones and use bKash (a mobile money service provider), including how to send money from one account to another and recharge mobile airtime. The 100 per cent timely payment rate (i.e. no overdue or late payment) through bKash shows a great opportunity to work more intensively in this sector and in more areas.[32]
	Standard Chartered commissioned Caribou Digital to assess the risks and benefits for girls of bringing their Goal program online. Goal is a global program focusing on sports and life skills education for girls in New Delhi and Lagos.[33]

[31] GSMA 2016, *Connected Women Programme*, https://www.gsma.com/mobilefordevelopment/programmes/connected-women, viewed on 27 December 2017.

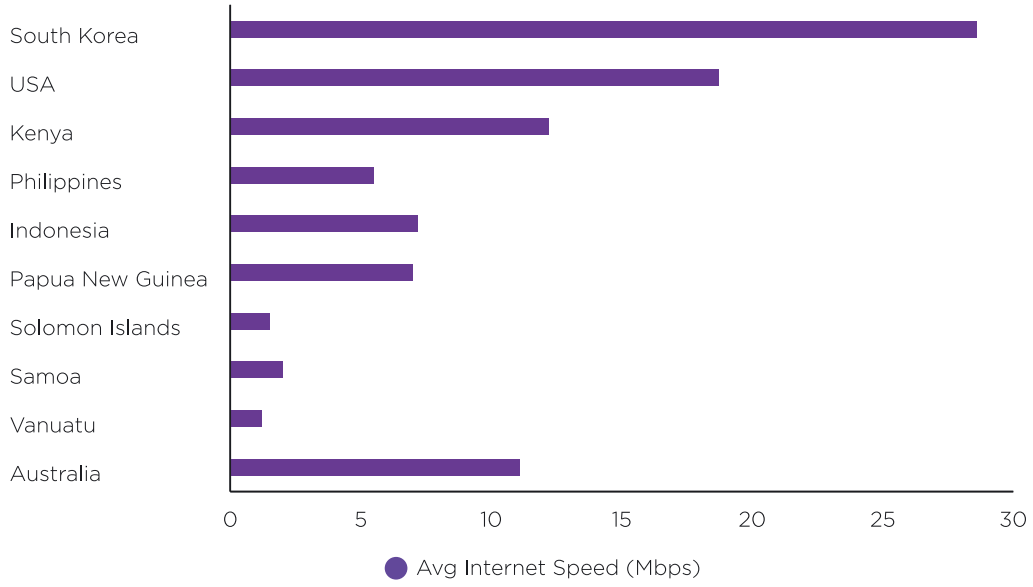
[32] GSMA 2017, *Empowering women through digital sanitation services*, https://www.gsma.com/mobilefordevelopment/programme/m4dutilities/empowering-women-through-digital-sanitation-services, viewed on 27 December 2017.

[33] Caribou Digital 2017, *How do girls in Lagos and New Delhi use technology?* http://cariboudigital.net/girls-lagos-new-delhi-use-technology, accessed on 27 December 2017.

2.1 Internet Connectivity

The Pacific region closest to the Chinese coast has benefited significantly from investment in sea cable telecommunications capacity, but further into the Pacific connectivity levels drop drastically. Pacific Island states have Internet access speeds averaging single digit Mbps, barely enough to be considered broadband. By contrast, Kenya has benefited from the significant growth in the number of submarine cables – from 16 to 42 cables between 2008 and 2016 – and has faster Internet download speeds than any Pacific region country, including Australia (Figure 6).

Figure 6: Average internet speeds (mbps) for select countries, 2017.



Source: Akamai (2017), *Internet connection speeds and adoption rates by geography*, https://www.akamai.com/us/en/about/our-thinking/state-of-the-internet-report/state-of-the-internet-connectivity-visualization.jsp.

A consequence of this relative lack of connectivity infrastructure for the region is lower levels of digital inclusion. Despite strong growth in mobile phone subscribers as a per cent of population, usage of Internet services lags by double-digit percentages.

A number of the experts consulted for this research emphasised the critical role of connectivity infrastructure in supporting inclusive development. Access to power, phone and data networks was seen as integral to increasing the impact of digital interventions. Numerous experts also commented on the particular challenges faced by the Pacific Islands where "the tyranny of distance and small populations" was leading to a proliferation of technology pilots, while large transformational investments would be more likely to produce significant development pay-offs. One expert, working for a major innovation funder in the region, highlighted the importance of

open-source innovation for connectivity in remote locations:

"Last mile connectivity is key to reaching the poorest. Ten to 20 million live without 2G or 3G access on remote islands... Private providers cannot see the commercial value in connecting them. They are working with a model that makes cell tower 90 per cent cheaper and under the control of the community. This 'community cellular network' works anywhere that there is backhaul connectivity including satellite – so would be applicable in the Pacific. The community cellular networks are built on open source technology, so they could be replicated across the Indo-Pacific. [This is why our] investment is always conditional on the technology being able to be affordable and accessible to those living on under $5 a day."

Remote areas often lack infrastructure to get people online because it is unprofitable for private telecommunications and Internet companies to install fibre-optic cables or build mobile towers to reach them. The reasons why private companies may decide not to extend or build infrastructure will vary from country to country and within them.

In countries such as Afghanistan, political instability can make investments in infrastructure unattractive.[34] In Pacific Island states, people are less likely to be online due to their remoteness, the expense of laying undersea fibre-optic cables and lack of economies of scale resulting from very small and scattered populations. Pacific Islands' vulnerability to climate change and extreme weather events makes infrastructure more prone to disruption. DFAT is working to influence factors constraining private sector investment, including by creating scalable shared value partnerships with the private sector.

Given that current private-sector models of expanding the Internet are having trouble reaching remote communities in the Indo-Pacific region, new solutions are needed from public sector donors, or public-private partnerships. In our interviews with experts, a range of approaches were seen as appropriate to different contexts – from convening donor conferences to extending the undersea fibre-optic cable backbone to "last-mile" connectivity solutions that bring power and digital communications to remote villages.

However many of these investments were not seen as being included in cohesive connectivity strategy, or with more centralised investments to enhance access. In Vanuatu, DFAT has leveraged the private sector to boost competition in the telecommunications industry and is part of efforts aimed at strengthening regional telecommunications, beginning with countries indicating high interest and with a high chance of success, in order to engage other countries for subsequent phases.

It is necessary to both understand the barriers preventing availability and adoption of Internet services, and to understand where new technology and business model innovations in connectivity can provide access to broader populations in harder to reach areas, in order to reach significant levels of adoption of Internet connectivity.

[34] BuddeComm 2017, *Afghanistan – Telecoms, Mobile and Broadband – Statistics and Analyses*, https://www.budde.com.au/Research/Afghanistan-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses, viewed on 27 December 2017.

TECHNOLOGY INNOVATIONS IN CONNECTIVITY

- **Satellite Innovations:** Some initiatives provide Internet access from air-based constellations of flying objects. OneWeb[35] and SpaceX,[36]plan to launch thousands of micro-satellites to provide ubiquitous, continuous Internet connectivity worldwide.
- **High Altitude Platform Stations:** Google's Project Loon seeks to do the same with balloons[37] and Facebook's Aquila project uses solar-powered drones.[38] Helion in Indonesia is sending Wi-Fi signals from the air using balloons tethered 200 meters in the air to provide a Wi-Fi-signal over a 300-metre radius.[39] Facebook is experimenting with helicopter-like drones.[40] These technologies offer great potential to connect unconnected populations and re-establish connectivity after natural disasters.
- **White-space Spectrum:** The shift to digital television broadcasting is freeing up low-frequency TV spectrum ranges, often known as white space. Whereas Wi-Fi frequencies cannot penetrate buildings, white space broadband can reach up to 10 kilometres and penetrate buildings and forests, making the technology especially valuable to remote locations in developing countries. In Nepal, social enterprise Picosoft uses white space to provide schools in rural villages with broadband access.[41] In 2016, Philippines-based start-up Wi-Fi Interactive Network received a $US 150,000 Microsoft grant to install 10,000 Wi-Fi hotspots, including those running on TV white spaces in places with coverage gaps.[42]
- **Wireless mesh networks:** These comprise interconnected radio nodes that share information with each other. Village Telco's mesh network connects phones (fixed-line or mobile) to a device known as a mesh potato, which then forms a cloud with other mesh potatoes, allowing them to connect with each other. Users can make phone calls, send text messages and access the Internet.[43] Village Telco first rolled out the system in Dili, East Timor, connecting 60 non-governmental organisations (NGOs).[44] As part of a wireless-for-communities program, the Internet Society partnered with government, local telecommunications and Internet companies to launch mesh Internet networks in rural Nepal and Pakistan.[45] New Zealand Red Cross and Flinders University in 2016 won the Pacific Humanitarian Challenge with Serval Mesh, which allows mobile phones to form impromptu networks consisting only of phones.[46]

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35 OneWeb 2017, *OneWeb*, http://oneweb.world/, viewed on 27 December 2017.
36 Khaw, C 2017, 'Elon Musk confirms fleet of SpaceX micro-satellites for 'very low cost' internet', in *The Verge*, https://www.theverge.com/2014/11/11/7192173/satellite-elon-musk-spacex, viewed on 27 December 2017.
37 X Development 2017, *Project Loon*, https://x.company/loon/, viewed on 27 December 2017.
38 Internet.org, *Connectivity Lab*, https://info.internet.org/en/story/connectivity-lab/, viewed on 27 December 2017.
39 Frieschlad, N 2016, 'Not waiting for Google, an Indonesian startup has its own Project Loon', in *Tech in Asia*, https://www.techinasia.com/helion-indonesian-version-of-google-project-loon, viewed on 27 December 2017.
40 Glaser, A & Wagner, K 2017, 'There's a small drone startup helping Facebook build its new internet-beaming helicopter drone', in *recode*, https://www.recode.net/2017/5/4/15364938/facebook-drone-startup-internet-beaming-helicopter-everfly, viewed on 27 December 2017.
41 Thapa, J 2017, 'Connecting the Unconnected Rural Schools of Nepal', in *OpenIDEO*, https://challenges.openideo.com/challenge/education-emergencies/ideas/connecting-the-unconnected-providing-access-to-connectivity-to-rural-community-schools, viewed on 27 December 2017.
42 Wintyme 2017, *WIN*, http://wintyme.com/, viewed on 27 December 2017.
43 Village Telco 2016, *About*, https://villagetelco.org/about/, viewed on 27 December 2017.
44 Village Telco 2016, *Dili Village Telco*, https://villagetelco.org/deployments/dili/, viewed on 27 December 2017.
45 Internet Society 2017, *Wireless for Communities*, https://www.internetsociety.org/what-we-do/where-we-work/asia-pacific/wireless-communities, viewed on 27 December 2017.
46 Bishop, J & Fierravanti-Wells, C 2016, *Winners of the Pacific Humanitarian Challenge*, https://foreignminister.gov.au/releases/Pages/2016/jb_mr_160506d.aspx, viewed on 27 December 2017.

BUSINESS MODEL INNOVATIONS IN CONNECTIVITY

- **Sharing infrastructure between telecommunication companies:** In places with multiple mobile operators, building shared networks reduces costs of expanding infrastructure for each company. In Tanzania, mobile operators Tigo, Vodacom and Airtel have launched six rural 3G pilot sites in identified priority coverage locations.[47] The tri-party rural roaming pilot enables the subscribers of other operators to roam with 3G data on their chosen sites.
- **Community-led off-grid connectivity:** Communities have built crowdsourced networks in at least 42 countries.[48] These are usually either wireless distributed mesh networks or easy-to-build telco infrastructure. Organisations such as Endaga, now part of Facebook, provide equipment to set up community-run mobile phone networks in remote areas with a "telco-in-a-box" product.[49] Social enterprises including Range Networks[50] and AlterMundi[51] work similarly. Others such as Maewo Telecommunications Committee in Vanuatu have formed charities to build community towers for rural villages.[52]

AFFORDABILITY OF INTERNET CONNECTIVITY

Even where the Internet is available it remains unaffordable for millions, impacting on adoption levels. However, just as availability varies both between and within countries, this is also true for affordability. In the Philippines, for example, the mobile market is dominated by a duopoly of two companies – Smart and Globe – which keeps mobile broadband prices high. These prices are prohibitively expensive for the bottom 40 per cent of Filipino society where the cost of a continuous mobile broadband connection is 29 per cent of average monthly income.

Improving affordability is strategically important to extending digital inclusion across the region. In general, donors are in a position to convene meetings of Indo-Pacific telecommunications regulators, provide expertise to stimulate effective market competition, and champion and reward the most inclusive pricing mechanisms. Regulation plays a vital role in establishing an enabling environment for inclusive digital development in the region. Organisations such as the Alliance for Affordable Internet would be key allies in this space.[53]

RELEVANCE OF CONTENT SERVICES AND LANGUAGE

A lack of awareness and locally relevant content are significant barriers to mobile Internet adoption in the Indo-Pacific region.[54] Awareness refers not just to knowing that a particular technology exists, but also to the individual's appreciation of its relevance to their own life. Technology developers often believe that if you build it they will come, and

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47 GSMA 2017, *Understanding the commercial challenges for mobile operators when expanding internet coverages to rural communities*, https://www.gsma.com/mobilefordevelopment/programme/connected-society/understanding-commercial-challenges-mobile-operators-expanding-internet-coverage-rural-communities, viewed on 27 December 2017.

48 Wiki30, *List of wireless community networks by region*, http://www.wiki30.com/wa?s=List_of_wireless_community_networks_by_region, viewed on 27 December 2017.

49 Endaga 2015, *Endaga*, https://www.endaga.com/, viewed on 27 December 2017.

50 Range Networks 2017, *Deployments*, https://rangenetworks.com/deployments/, viewed on 27 December 2017.

51 Rego, LN 2015, *AlterMundi: "Community networks embody the original spirit of the internet"*, https://www.apc.org/en/news/altermundi-%E2%80%9Ccommunity-networks-embody-original-spirit-internet%E2%80%9D, viewed on 27 December 2017.

52 Maewo Telecommunications Committee 2016, *Maewo Community Action Group Fundraising for Solar Powered, Critical Communications Link*, http://mtc.invanuatu.com/maewo-community-action-group-fundraising-for-solar-powered-critical-communications-link, viewed on 27 December 2017.

53 Alliance for Affordable Internet 2017, *Alliance for Affordable Internet*, http://a4ai.org/, viewed on 27 December 2017.

54 GSMA Intelligence 2016, *The Mobile Economy: Asia Pacific 2016*, GSMA, London.

underestimate the importance of local market relevance and awareness building.

Experts consulted flagged a lack of a participatory approach in many technology investments in the region. 77 per cent of Internet content is in just 10 languages.[55] The issue of accessible content is even more prevalent in Pacific Islands states where in the Melanesian Islands (includes PNG, Vanuatu, Fiji, and the Solomon Islands) there are over 1,000 languages spoken with some having no form of writing.[56] For users who do not speak one of the 10 serviced languages, accessible content is often hard to come by.

One tangible approach to building awareness is to start technology investments with a focus on locally and nationally determined needs, and appropriate digital approaches. Supporting models of co-creation of digital services leads to more sustainable outcomes. More generally, regional investments by donors in local language ICT development, such as with the International Development Research Centre Pan Asia localisation initiative, were seen as positive moves that could be further built upon.

Experts consulted highlighted that a greater degree of awareness is needed amongst government officials, who need to understand better the potential of digital technologies to transform their cities and countries. Donors also need to consider sustainable investments, with one regional expert commenting that they were more willing to fund the piloting of new technology for "quick wins" than making the longer term investment in awareness building necessary to scale innovations. The lack of "patient capital" was flagged as an issue more generally inhibiting transformative digital development.

DIGITAL LITERACY AND ACCESSIBILITY ISSUES

Digital literacy, or being able to use a computer, mobile phone or other digital device, is a basic skill required to access digital technologies. Particular groups, such as the elderly, women and those from lower income groups, may be less likely to have digital literacy skills to receive the benefits from digital technologies. Experts consulted from South East Asia pointed out that many countries in the region were having trouble improving digital literacy skills fast enough to meet the needs of the economy. In some Indo-Pacific countries, technical skills are developed in isolation from the critical and problem-solving skills needed to apply to real-world problems.

Physical ability to access digital technologies is another barrier. One in six people living in the Asia Pacific, amounting to some 650 million men, women and children, has some form of disability.[57] People with a disability living on low incomes are among the most marginalised in the region. They can face exclusion from access to education, employment, social protection and legal support, and are subject to disproportionately high poverty levels. Technologies that are designed in ways that are inaccessible to already marginalised people risks adding further layers of disadvantage and exclusion.

Technology can present exciting opportunities for donors to work with countries to improve accessibility, especially given that many developed countries have deep expertise in assistive technologies for people living with disabilities.[58] Australia's experience in developing a National Transition Strategy for Web Accessibility and a Digital Service Standard for example could be drawn on to support improving

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55 Miniwatts Marketing Group 2017, *Internet World Users by Language: Top 10 Languages*, http://www.internetworldstats.com/stats7.htm, viewed on 27 December 2017.

56 Landweer, ML & Unseth, P 2012, 'An introduction to language use in Melanesia', *International Journal of the Sociology of Language*, vol. 2012, issue 214, pp. 1–3.

57 United Nations Economic and Social Commission for Asia and the Pacific 2017, *Disability*, http://www.unescap.org/our-work/social-development/disability, viewed on 27 December 2017.

58 Australian Disability Clearinghouse on Education and Training, *Assistive Technology*, https://www.adcet.edu.au/oao/assistive-technology/, viewed on 27 December 2017.

digital accessibility.[59] Convening networks between expert agencies[60] and disability organisations in Indo-Pacific could also help build relationships that produce significant digital inclusion dividends across the region.

GENDER BARRIERS TO ADOPTION OF INTERNET AND DIGITAL SERVICES

While technology offers substantial opportunities to provide protective, economic, social and political benefits to women, it can also exacerbate inequalities and increase risks to women's safety when not implemented well. Power architectures in many societies and families prevent women from owning technology and using digital services. The GSMA Connected Women program has identified a gender gap of 200 million women in lower-income countries who don't have access to mobile and digital technology at the same level as men in their societies.[61]

There has been an emergence of new forms of violence against women enabled by technology. For example in India, many women are reluctant to share their mobile number with the mobile agent during top-up, for fear of subsequent harassment. As a protective measure, Vodafone India has developed a SIM card package where subscribers can top up anonymously using a one-time password instead of their mobile phone number. Vodafone estimates that more than 80 per cent of these customers are rural women.[62]

Recent research in South-East Asia points to the unique barriers women face accessing connectivity, such as being denied access by gatekeepers in their family or community, lack of confidence or perceived need, and a fear of the negative aspects of the internet and how this may affect their reputation.[63] Through Caribou Digital's research on Digital Lives for the MasterCard Foundation, gender-segmented focus groups showed that women constantly talk down their levels of technology usage even when they are more proficient in using it than men.[64]

The under-representation of women and girls in Science, Technology, Engineering and Maths (STEM) subjects across the region means that there is also a need for a gender-aware approach in this regard. Many donors consulted already have strong links through academic education partnerships across the region. Building on this success, partnerships in technical and vocational education and private sector training could boost ability levels and have a multiplier effect across the region. For example, Australia's worldwide leadership in open and online distance learning could be the basis for potentially catalytic investment for many Pacific Island states.[65]

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59 Digital Transformation Agency 2017, *Digital Service Standard*, https://www.dta.gov.au/standard/, viewed on 27 December 2017.

60 Assistive Technology Australia 2017, *Assistive Technology*, https://at-aust.org/home/assistive_technology/assistive_technology, viewed on 27 December 2017.

61 GSMA Mobile for Development 2016, *Connected Women Programme*, https://www.gsma.com/mobilefordevelopment/programmes/connected-women, viewed on 27 December 2017.

62 GSMA Mobile for Development 2017a, *Triggering mobile internet use among men and women in South Asia*, https://www.gsma.com/mobilefordevelopment/programme/connected-women/triggering-mobile-internet-use-among-men-women-south-asia, viewed on 2 January 2018.

63 GSMA Mobile for Development 2017a

64 Caribou Digital 2015, *Our Work 3 – Digital Lives in Ghana Kenya and Uganda*, http://cariboudigital.net/digital-lives-ghana-kenya-and-uganda/, viewed on 27 December 2017.

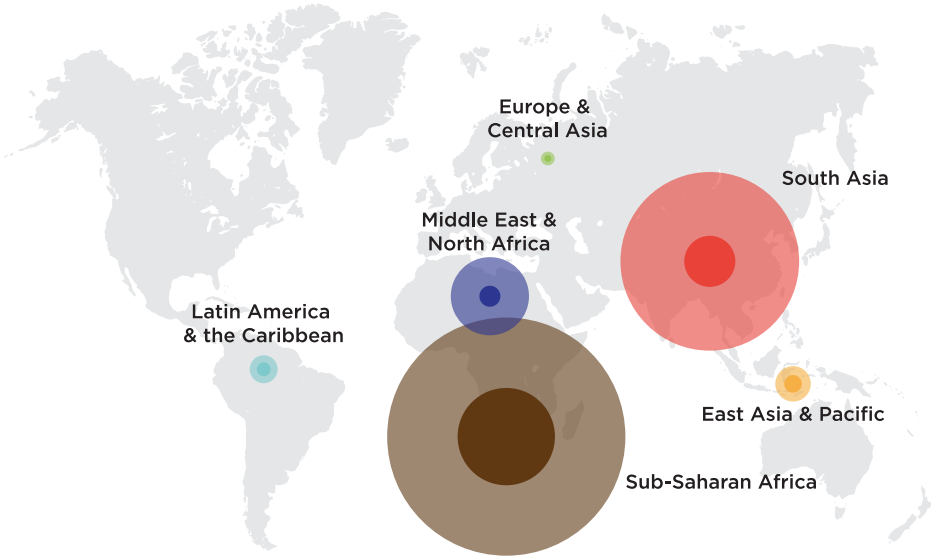
65 Moodle 2017, *Moodle HQ*, https://moodle.com/hq/, viewed on 27 December 2017.

2.2 Digital Financial Services

GROWING MOBILE MONEY ECOSYSTEMS WORLDWIDE

Digital financial services could spur inclusive economic growth that adds US$3.7 trillion to the GDP of emerging economies within a decade.[66] The growth of mobile money markets and products has helped facilitate greater access. In 2016, the number of registered mobile money accounts globally surpassed half a billion (556 million).[67] Increasingly, mobile money is a key driver of economic growth in emerging markets, particularly through formalising payments, increasing transparency and boosting GDP. While the figure below does not disaggregate the data, access to digital financial services, including remittances, can be highly gendered.

Figure 7: Number of registered and active mobile money customers, by region (90-day, December 2016).[68]



Source: GSMA 2017, State of the Industry Report on Mobile Money. Decade Edition: 2006 – 2016, GSMA, United Kingdom. p.17.

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66 Better than Cash Alliance for the G20 Global Partnership for Financial Inclusion, *Building Inclusive Digital Payments Ecosystems: Guidance Note for Governments,* http://www.gpfi.org/publications/gpfi-guidance-note-building-inclusive-digital-payments-ecosystems, viewed on 2 January 2018.

67 GSMA Mobile Money 2017, *State of the Industry Report on Mobile Money. Decade Edition: 2006 – 2016*, GSMA, London.

68 A mobile money service enables its users to transfer money and make payments using a mobile phone, and is available to those without an account at a financial institution. Mobile banking services, such as Apple Pay, WeChatPay or AliPay, offer mobile as a channel to access a traditional banking product, or a payment service linked to a traditional banking product or credit card.

While today most mobile money services are used for domestic transactions, international transfers represent the fastest growing mobile money product line – mobile money can be used for international transfers in 51 of the 92 countries where the service is available.[69] Migrant workers sending money home are increasingly driving the advancement of mobile money services.

USING MOBILE MONEY FOR INTERNATIONAL REMITTANCES

Over the past decade, remittances to Asia and the Pacific increased by 87 per cent, reaching $US 244 billion, while migration grew by only 33 per cent in comparison. In East Asia and the Pacific, the volume of remittances to low and middle income countries is expected to grow from $US 122.7 billion in 2016 to $US 137.3 billion by 2019.[70]

Remittances are an important source of income for several pacific countries. Tonga is among the top remittance-receiving countries in the world where 70 per cent of adults reported receiving remittances in 2015.[71]

A majority of remittances in the region are sent through traditional money transfer operators such as Western Union – 83 per cent in Tonga, 68 per cent in the Solomon Islands and 92 per cent of international remittances for Samoa.[72] The origin of remittances varies by country. While nearly all remittances in Samoa are sent from abroad, the majority of remittances received in the Solomon Islands and Vanuatu are domestic – 89.2 per cent for the Solomon Islands and 75 per cent for Vanuatu.[73]

Average costs to use digital financial services vary among Indo-Pacific sub-regions but are high compared to other global regions. Costs to send remittances to Central Asia in corridors originating from the former Soviet Union are still among the lowest in the world, at about 3.5 per cent. In comparison, Eastern Asia (10.3 per cent) and the Pacific (11.5 per cent) remain the destinations with the highest costs in Asia.[74] The cost of remittances in the Pacific is the highest after Sub Saharan Africa.

Taking the example of Tonga, fees from Western Union[75] combined with currency fluctuations and the cost to travel to a Western Union location may reduce the final amount of money that a person receives in hand. Tongan adults are likely losing over 25 per cent of the original remittance amount because of these costs.

The Australian Government is already lowering the costs and risk of remittances across the region. Costs of remittances sent from Australia, at 8.84 per cent, have reduced by more than 5 percentage points since 2011, and are only slightly higher than the global average cost of 7.21 per cent.[76] Australia's National Remittance Plan outlines how it is pursuing accessible and affordable remittance flows in support of the G20's alignment with the SDG target to reduce the cost of remittance transfers to less than 3 per cent. [77]

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69 GSMA Mobile Money 2017, *Guidelines on International Remittances through Mobile Money*, GSMA, London.

70 Ratha, D, De, S, Schuettler, K, Seshan, G, Desiree & Yameogo, ND 2017, *Migration and Development Brief 28, Migration and Remittances: Recent Developments and Outlook*, World Bank.

71 Pacific Financial Inclusion Programme 2016a, *Financial Services Demand Side Survey Tonga*, National Reserve Bank of Tonga, Tonga.

72 Pacific Financial Inclusion Programme 2016b, *National Demand Side Surveys*, http://www.pfip.org/our-work/work-streams/market-information/national-demand-side-surveys/, viewed on 27 December 2017.

73 Pacific Financial Inclusion Programme 2016b.

74 International Fund for Agricultural Development 2017, *Sending Money Home: Contributing to the SDGs, one family at a time*, International Fund for Agricultural Development, Rome.

75 Pacific Financial Inclusion Programme 2016a.

76 World Bank, *Remittance Prices Worldwide*, http://remittanceprices.worldbank.org/en, viewed on 2 January 2018.

77 GPFI. 2017, *G20 National Remittance Plan 2017 Australia*, https://www.gpfi.org/sites/default/files/Australia%20-%20G20%20National%20Remittance%20Plan%202017.pdf, viewed on 2 January 2018. Australia has also been involved in developing the G20 GPFI resources, for example the emerging policy approach to digital inclusion http://www.gpfi.org/publications/g20-report-digital-financial-inclusion-emerging-policy-approaches and the guidance note on building inclusive digital payment ecosystems http://www.gpfi.org/publications/gpfi-guidance-note-building-inclusive-digital-payments-ecosystems

BARRIERS TO ADOPTION OF DIGITAL FINANCIAL SERVICES

Local relevance, language and literacy barriers need to be overcome, as finance interfaces that seem natural to Western users make no sense amongst local cultures. Research from Microsave indicates how the plus symbol to add funds to a digital wallet is interpreted by many users as the Red Cross symbol.[78] As discussed in the connectivity section above, understanding levels of digital literacy, interface design, and taking local language and cultural norms into account are all important for take up of digital financial services.

Digital financial services are important to advancing financial inclusion more broadly, as digitising services can help address many of the barriers to financial inclusion in the region, including physical access, lack of identity and the cost of providing large volumes of services at small financial values.

Societal barriers to financial inclusion that impact women and marginalised groups' ability to adopt digital financial services must also be identified and addressed. Women in developing countries are 9 per cent less likely than men to own a bank or other financial account, and 18 per cent less likely to own an account in South Asia. Resources, such as those produced by the G20's Global Partnership for Financial Inclusion, are available to help implementers ensure the benefits of digital financial services can be accessed by all.[79]

There is still a preference for cash based transactions in some places – for example, a vast majority of the Pacific Islanders prefer using cash (88 per cent in Fiji, 57 per cent in Samoa).[80] People tend to prefer cash for its convenience, to avoid fees and for ease of budgeting. While mobile coverage in the Indo-Pacific region has vastly improved in recent years covering more than 90 to 95 per cent of the population, more rural and isolated populations (as it is often the case in the Pacific nations) have unreliable or no access to mobile networks.

DIGITAL FINANCIAL SERVICES AS A PLATFORM FOR INNOVATION

In the same way that Internet connectivity paves the way for innovations such as digital finance, this innovation also paves the way for a host of further innovations. Mobile money and digital financial services have provided the enabling architecture for a range of innovations in energy and water access, education, and many other sectors.

As an example, M-KOPA in Kenya is a solar company providing access to affordable solar units for small homes in low-income areas of East Africa.[81] Initially launched in Kenya, it has spread to many neighbouring countries and has in excess of half a million customers. The premise is simple; a solar unit comprising a small solar panel, a control unit enabled with a mobile SIM card, and an array of lights and charging cables is supplied to the customer for a very low deposit, usually less than $10. The unit cost is between $100 and $200 for all the equipment, which is beyond the spending power of most low-income users. The service is made affordable using mobile money payments to switch on the unit daily, allowing access to the solar power. Daily payment is usually matched to the amount that customer would normally spend on kerosene for lighting and phone charging. After a year of daily payments, the system is paid off and customers have free solar power for their home.

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78 MicroSave 2017, *Designing Mobile Wallet for the Poor*, http://www.microsave.net/resource/designing_mobile_wallet_for_the_poor?platform=hootsuite, viewed on 27 December 2017.

79 See for example: *Digital Financial Solutions to Advance Women's Economic Participation* http://www.gpfi.org/publications/digital-financial-solutions-advance-womens-economic-participation, and Building Inclusive Digital Payments Ecosystems http://www.gpfi.org/publications/gpfi-guidance-note-building-inclusive-digital-payments-ecosystems.

80 Pacific Financial Inclusion Programme 2016b.

81 M-KOPA 2017, *M-KOPA Solar*, http://www.m-kopa.com/, viewed on 27 December 2017.

In Vietnam, a partnership between The Asia Foundation, Vietnam Bank for Social Policies and MasterCard – supported by DFAT through the Business Partnerships Platform – is deploying the first mobile banking platform for low income populations.[82] By increasing and improving access to a full range of digital financial services for those who lack access to traditional banking services, this initiative aims to accelerate economic opportunities for low-income households, including women-led microenterprises.

The Consultative Group to Assist the Poor characterises these innovations as Digital Finance Plus and has written extensively on the potential for digital financial services to provide the stimulus for innovation in many sectors.[83] In partnership with the UK Department for International Development (DFID), the GSMA Mobile for Development Utilities program has been funding innovations in the intersection between mobile money and utilities since 2013, showing that these services can scale and replicate across markets, providing affordable access to energy and water for millions of people.[84]

THE NEXT WAVE OF DIGITAL FINANCIAL SERVICES – MESSAGING AS PAYMENTS

As indicated previously, the majority of digital payments and mobile money payments are person-to-person (P2P) – often remittances sent from cities to rural villages, or through major remittance corridors such as the significant amount of money that is sent internationally home to families in the Philippines.

This suggest that other successful digital innovations that are primarily P2P in their usage – namely messaging services – are primed to enter the digital financial services space. As mobile operators have competed successfully with traditional banks by offering digital branchless banking services to their users, messaging service providers are starting to compete with mobile operators on the next wave of digital financial services.

As noted in Section 1, the success of digital payments in China has shown the vast and fast growth that can be achieved, but they are by no means alone. WhatsApp is launching a P2P payment services in India and with dominance of the messaging market in India, sub-Saharan Africa and many over low-income markets, it could become a major competitor to mobile operator mobile money services.[85] Also in India, Google has launched Tez, an innovative P2P payment service that uses audio technology to make the service work even on basic feature phones.[86]

What is notable about India as a market for these innovations is the way that government-funded infrastructure has provided the backbone for innovators to build upon. In particular for payments, the Indian unified payments interface service provides simple interfaces into many banks for new players, which is itself built upon the Aadhaar digital identity service discussed in the next section.[87] This demonstrates how a government actor providing a common good technology creates a springboard for many innovators.

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82 DFAT 2017, *Mobile banking for the poor in Vietnam*, http://dfat.gov.au/aid/who-we-work-with/private-sector-partnerships/bpp/Pages/mobile-banking-for-the-poor-in-vietnam.aspx, viewed on 27 December 2017.

83 Consultative Group to Assist the Poor 2017, *Digital Finance Plus*, http://www.cgap.org/topics/digital-finance-plus, viewed on 27 December 2017.

84 GSMA, *M4D Utilities*, https://www.gsma.com/mobilefordevelopment/programmes/m4dutilities, viewed on 27 December 2017.

85 Vincent, J 2017, 'WhatsApp will launch its first digital payments service in India', in *The Verge*, https://www.theverge.com/2017/4/6/15204018/whatsapp-payment-service-india-launch-coming, viewed on 27 December 2017.

86 Google 2017, *Tez*, https://tez.google.com/, viewed on 27 December 2017.

87 Cashless India 2016, *Unified Payments Interface (UPI)*, http://cashlessindia.gov.in/upi.html, viewed on 27 December 2017.

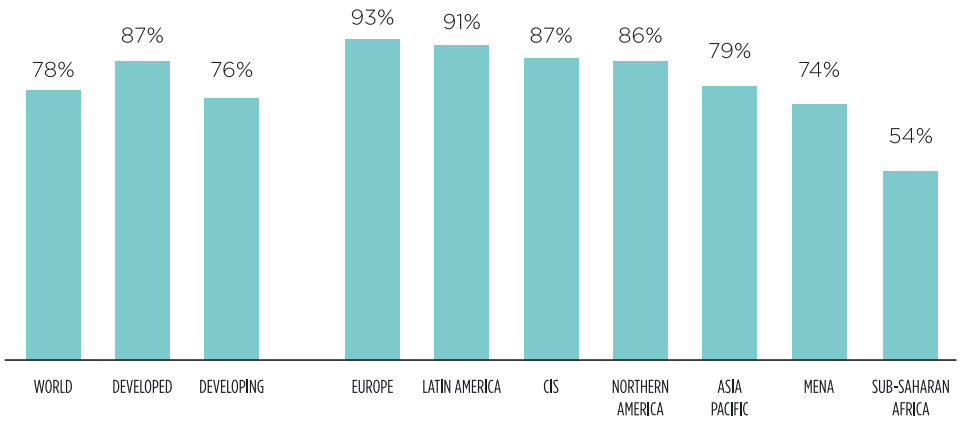
The Bill & Melinda Gates Foundation has been the most active donor working with the Indian Government to promote this. Via its Level One program, they have built an open-source, free payments interface and interoperability platform to encourage more countries to enable this platform. This is now being run as Mojaloop, a complete free software codebase to encourage open payment interfaces for digital financial services.[88]

2.3 Digital Identity

Around the world today there are approximately 1.1 billion people who lack an official form of identification. A digital identity is the cornerstone of existing in the digital age. Without some form of identity within the global digital networks we live with, it is impossible to fully reap the rewards these platforms offer.

Universally accessible identity documents for all citizens should be a basic right, as stated in the Sustainable Development Goal 16.9 – to provide legal identity for all, including birth registration, by 2030. Yet a number of barriers exist that limit access to identity services.[89] This includes barriers such as cost, inefficient and fragmented registration systems, lack of perceived benefit, discriminatory policies, and illiteracy, all of which tend to disproportionally affect the most vulnerable citizens, including women and girls. These challenges are particularly acute in Sub-Saharan Africa, Middle East and North Africa and Asia Pacific (see Figure 8).

Figure 8: Registration levels in Sub-Saharan Africa compared to other regions as a percentage of country GDP.



Source: Lynch, S 2017, *Definitions of Identity – Legal/official Identity*, https://www.gsma.com/mobilefordevelopment/programme/digital-identity/definitions-identity-legalofficial-identity, viewed on 27 December 2017, p. 3.

[88] Mojaloop 2017, *mojaloop*, http://mojaloop.io/, viewed on 27 December 2017.
[89] Lynch, S 2017, 'Definitions of Identity – Legal/official Identity', in *GSMA*, https://www.gsma.com/mobilefordevelopment/programme/digital-identity/definitions-identity-legalofficial-identity, viewed on 27 December 2017.

Digital identities can be created by the user on private sector platforms. Most users will have created email addresses, Facebook accounts and received a mobile phone number as they adopted digital services, and these systems will slowly accrue knowledge of that user's lifestyle and behaviours as they use the service. This is a user-created digital identity, and although most won't have read the terms and conditions for platforms such as Facebook in detail, there is a general level of acceptance that to receive a service for "free" the user permits their personal data to build a digital identity within that platform. And these services are often used as proxies to authenticate identities on other platforms – Facebook, Google and LinkedIn all allow their user identity data to be used to sign in for third-party services online, and open-source projects such as OAuth[90] and the Open Internet Exchange strive to keep interoperability between these private sector platforms open.[91]

There is an irony in the fact that users seem willing to share personal data with these private sector systems on a daily basis, whereas government-led digital identity platforms have often come up against concerns about surveillance by the state, despite these ascribed identities often having much lower levels of personal data retention that the private sector actors. Government digital identity programs also have to grapple with whether they are acting as an authenticator of identity purely to enable transactions with the state – i.e. to register for social payment programs – or whether they want to enable full legal citizenship to be ascribed via digital identity. This final level of identity service is only enabled by a few countries worldwide, most notably Estonia who even offer e-residency of their country via a digital identity, raising interesting question about national boundaries and citizenship in the digital age.[92]

Addressing issues of exclusion is crucial. Digital identification system technologies could bring into formal visibility people who have long been marginalised, vulnerable, and excluded. Digital identity can have different implications for women and men, and for marginalised groups – and particular implications for women's safety and access to social protection programs. It is important to actively facilitate access to digital identify for all populations because of its conduit to services (such as bank accounts and mobile phones) and the ability to claim basic rights (for example, to education and social protection or even to travel freely).

The digital security company, Gemalto, suggests that the technological and policy advancements made in the past year make digital identification systems "one of the most significant technology trends on the planet."[93] Countries from around the Indo-Pacific region lead in trialling and scaling up digital identification systems. Malaysia was one of the earliest

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90 OAuth 2017, *OAuth*, https://oauth.net/, viewed on 27 December 2017.

91 Open Identity Exchange 2017, *The Open Identity Exchange*, http://www.openidentityexchange.org/, viewed on 27 December 2017.

92 Republic of Estonia 2017, E-Residency, https://e-resident.gov.ee/, viewed on 27 December 2017.

93 Gemalto 2017, *Digital identity trends – 5 forces that are shaping 2017*, http://www.gemalto.com/govt/identity/digital-identity-trends, viewed on 27 December 2017.

adopters,[94] and its MyKad system is quite advanced.[95] Indonesia followed shortly, but faces challenges reaching full adoption.[96] India's Aadhaar card system has received much attention for rapidly achieving near universal coverage, as discussed in the case study below. Thailand[97] and Singapore are following suit.[98]

Meanwhile, other countries in the region are trying to catch up. Pakistan has a national identification (ID) card that has been nearly universally adopted.[99] While the ID itself is not part of a digital system, some digital services are integrating it – for example, for easier and more accessible registration of births.[100] Bangladesh has replaced voter ID cards with smart cards containing extensive personal and biometric data.[101] This means that people could also possibly use them for other digital services, including as a driver's licence or bank card. The Government of Nepal partnered with private company Safran, which was involved in India's Aadhaar system, to develop a similar system.[102]

BARRIERS TO ADOPTION OF DIGITAL IDENTITY SERVICES

Notwithstanding security and privacy concerns over governments collecting personal information,[103] as part of a wider system of digital trust, digital identification systems could give citizens more power and control in society than they give to the state.[104] To achieve a system that navigates the trade-offs between trust, security and privacy on one side and equality of access on the other, certain enabling conditions must be in place.

It is also helpful if a high degree of digital literacy and technological capabilities exist in government agencies that will build or become integrated into digital identification systems. Government and policy support for open data[105] (and ideally open accountability) are also important to ensure public observers can scrutinise and strengthen technology and data standards.[106] Open technologies also maximise flexibility and interoperability of systems, making it easier for digital identification systems to evolve and adapt as standards and technologies evolve.

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94 Knight, W 2001, 'Malaysia pioneers smart cards with fingerprint data', in *New Scientist*, https://www.newscientist.com/article/dn1331-malaysia-pioneers-smart-cards-with-fingerprint-data/, viewed on 27 December 2017.

95 Madanapalle, A 2017, 'How Aadhaar compares to other biometric national identification systems around the world', in *Tech 2*, http://www.firstpost.com/tech/news-analysis/how-aadhaar-compares-to-other-biometric-national-identification-systems-around-the-world-3700543.html, viewed on 27 December 2017.

96 Basu, M 2016, 'Indonesia misses national smart ID cards deadline', in *GovInsider*, https://govinsider.asia/digital-gov/indonesia-misses-national-smart-id-cards-deadline/, viewed on 27 December 2017.

97 Lee, J 2017, 'Thailand government introduces fingerprint ID for SIM card registration', in *BiometricUpdate.com*, http://www.biometricupdate.com/201702/thailand-government-introduces-fingerprint-id-for-sim-card-registration, viewed on 27 December 2017.

98 Tab, A 2017, 'What it takes for Singapore's digital ID system to succeed', in *ComputerWeekly.com*, http://www.computerweekly.com/feature/What-it-takes-for-Singapores-digital-ID-system-to-succeed, viewed on 27 December 2017.

99 Ministry of Information Technology 2017, *Digital Pakistan Policy 2017*, Ministry of Information Technology.

100 GSMA Digital Identity 2017, *Driving Adoption of Digital Identity for Sustainable Development: An End-user Perspective Report*, GSMA, London.

101 Election Commission Bangladesh 2015, *National Identity Registration Wing*, http://www.nidw.gov.bd/, viewed on 27 December 2017.

102 Find Biometrics 2016, *Safran Offers More Details on Nepal ID Project*, https://findbiometrics.com/safran-nepal-id-project-309011/, viewed on 27 December 2017.

103 Nyst, C, Pannifer, S, Whitley, & Makin, P 2016, *Digital Identity: Issue Analysis*, Consult Hyperion.

104 Spinks, R 2016, 'Do we trust digital identification?' in *The Guardian*, https://www.theguardian.com/media-network/2016/jul/25/do-we-trust-digital-identification, viewed on 27 December 2017.

105 GSMA Digital Identity 2016, *Regulatory and policy trends impacting Digital Identity and the role of mobile: Considerations for emerging markets*, GSMA. London.

106 McWaters, J 2016, *A Blueprint for Digital Identity: The Role of Financial Institutions in Building Digital Identity*, World Economic Forum, p. 72.

Perhaps paradoxically, while digital technologies such as these ID systems are meant to either build trust or create systems where trust between actors is less necessary, a context where little trust already exists can preclude implementing these technical solutions. For example, in the early 2000s, the United Kingdom (UK) Government considered but ultimately rejected introducing a national biometric ID card system.[107] The issue became politicised, with a strong backlash from citizens who indicated a lack of trust in the state's ability to carry out surveillance ethically or appropriately.[108] However the level of controversy was not the same elsewhere in the EU.[109]

[107] London School of Economics and Political Science 2005, *The Identity Project: an assessment of the UK Identity Cards Bill and its implications*, the Department of Information Systems, the London School of Economics and Political Science, London.

[108] Electronic Frontier Foundation, *Success Story: Dismantling UK's Biometric ID Database*, https://www.eff.org/pages/success-story-dismantling-uk%E2%80%99s-biometric-id-database, viewed on 28 December 2017.

[109] Ng-Kruelle, G, Swatman, PA, Hampe, JF & Rebne, DS 2006, 'Biometrics and e-Identity (e-Passport) in the European Union: End-user perspectives on the adoption of a controversial innovation', *Journal of Theoretical and Applied Electronic Commerce Research*, Vol. 1, No. 1, pp. 12 – 35.

CASE STUDY

Aadhaar Digital Identity system in India

By far the most feted government identity program is that of Aadhaar in India, with a reported adoption level totalling a billion users. Whilst it does not represent legal citizenship status, and is notionally a voluntary program, it has rapidly become the de facto identity artefact used in Indian society. More importantly the success of the Aadhaar has provided another key infrastructural building block for the Indian technology sector, creating a wealth of new innovations and entrepreneurs.

The India Stack is a project from a team of developers to create a series of application program interfaces (APIs) that use the Aadhaar system to make it easy for people to register and authenticate themselves for all kinds of transactions.[110] This has created a second wave of Indian information technology (IT) sector development – but this time as entrepreneurs building digital services to address the rapidly digitised India market, as opposed to the IT outsourcing industry that represented the first wave of the sector. Companies such as Yooz[111], Babajob[112] and others have used the infrastructure from the India Stack to verify their customer's identity.

This focus on building a digital identity platform that is widely adopted and easy to use – requiring only an ID number matched to a biometric (fingerprint or iris-scanned) proof – may have created a broad user base but has not avoided controversy. Primarily a system that was launched as being voluntary has become mandatory by default, as an increasing number of government services started to require an Aadhaar number to use them. This prompted the Supreme Court of India to rule on privacy, and to reinforce that Aadhaar is meant to be a voluntary system.[113]

Also, whilst Aadhaar was built and deployed to allow low-income and illiterate users to adopt the system, it never had any formal user-centric research conducted during the design stage, meaning that the needs of many vulnerable groups were not met by the way the service has been deployed.[114] There are often inconsistencies in names used within the system, problems registering, and gender issues as women's Aadhaar artefacts are often withheld by in-laws or husbands as a form of control.

This was most noticeable during the demonetisation of 2016 when a number of low-value Rupee notes were removed from circulation. Women who had hoarded cash from their husbands and husband's family to maintain some economic independence were forced to exchange their notes for the new ones or register for a new bank account requiring ID documents and Aadhaar numbers, exposing the money they held for themselves.

Aadhaar continues to be monitored as the largest-scale national identity initiative yet seen in the world, and programs such as the World Bank's Identification for development work to replicate similar projects in other countries,[115] while ID Insight's State of Aadhaar annual report is carefully monitoring progress to make sure it meets end-user needs.[116]

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110 IndiaStack 2017, *Technology for 1.2 billion Indians*, http://indiastack.org/, viewed on 28 December 2017.
111 Yooz 2017, *Welcome to Yooz*, https://www.yooz.money/, viewed on 28 December 2017.
112 Babajob 2017, *Better jobs for everyone*, http://www.babajob.com/, viewed on 28 December 2017.
113 Krishna, G 2017, 'Supreme Court Says Aadhaar Act Keeps UID/Aadhaar Voluntary As Well', in *LiveLaw.in*, http://www.livelaw.in/supreme-court-says-aadhaar-act-keeps-uidaadhaar-voluntary-well/, viewed on 28 December 2017.
114 For more discussion on vulnerable users of Aadhaar, see Identities 2017, *Identities Research Project*, https://www.identitiesproject.com/, viewed on 28 December 2017.
115 World Bank 2017, *Identification for Development (ID4D)*, http://www.worldbank.org/en/programs/id4d, viewed on 28 December 2017.
116 Abraham, R, Bennett, E, Sen, N & Shah, NB 2017, *State of Aadhaar Report 2016–17*, ID Insight, New Delhi.

3 – Innovation

3.1 The landscape of digital innovation

Beyond the three basic building blocks of digital innovation, emerging technologies are starting to impact the development sector ranging from innovations building on increased data capture to new software and hardware platforms. These technologies are exciting; they have the potential to rapidly address large-scale economic, social or political challenges. However, as they may not yet have been developed into viable market solutions or been taken up in development practice, they offer new risks and uncertainties, and have the potential to displace existing technologies and labour forces. Risks in relation to gender include the emergence of new forms of violence against women enabled by technology (notwithstanding that technology can be used as a protective measure). A structured approach to assessing and managing the risks in partnership with experts will help development actors to take advantage of the opportunities presented by these technological innovations responsibly.

Table 3: Examples and potential development usages of digital innovation.

Innovation	Example	Potential Development Usage
Data Innovations	■ Big Data ■ Open Data ■ Citizen-generated Data	■ Improved understanding of user behaviour and the world around us. ■ Reduced risk and effort in development interventions based on better information. ■ More open societies and platforms for innovation.
Software Innovations	■ Blockchain ■ Artificial Intelligence ■ Machine Learning ■ Natural Language Processing	■ Entirely new financial and contracting systems that are more resilient to fraud and crime. ■ Increased speed of analysing complex problems. ■ Improved localisation.
Hardware Innovations	■ Drones ■ Internet of Things ■ Smart Cities ■ 3D Printing	■ Providing accessibility for medicines and other small deliverables in regions without road transport. ■ Increasing ability to survey remote areas. ■ Improving town and city infrastructure by increasing availability of smart utilities. ■ Making manufacturing local, reducing the need to ship physical products.

3.2 Data Innovations

Data is central to the successful operation of digital platforms, and one of the major by-products of increased use of these platforms is the creation of more data. Three areas are of particular interest for digital development: big data, open data and citizen data.

Big data is categorised as having greater volume, velocity and variety than a typical data set. Open data is free for anyone to access, use and reuse. Citizen-generated data refers to data that citizens actively collect and use. Although it is useful to distinguish between them, the three areas overlap and their greatest value often comes from combining them rather than treating them in isolation.

For example, one of the most remarkable examples of DFAT contribution in this space was an investment in real-time and open data management within the Indonesian government's social protection system. According to experts involved, the project created a unified data management system and supported a live census recording all beneficiaries of social welfare and subsidies and then matches them with state government utilities to align with disbursement. An investment of a few million dollars has led to cost savings of around $1.2 billion for the Indonesian Government.

BIG DATA

In general, big data is touted for its potential to help development actors extract better insights from historical data, uncover issues as they happen, forecast which issues or events may occur next and prescribe potential solutions. Big data provides us with new ways of visualising and tackling development issues. Visualisation tools such as dashboards used to be largely static and updated infrequently. Today, inclusion of novel data sources uploaded continuously allows us to generate fluid visualisations that enhance capacity to tackle issues as they unfold.

Call record details from 15 million Kenyans, for example, were used in a pilot to generate maps to predict which areas in the country would be susceptible to malaria outbreaks based on mobile-phone user travel patterns.[117] Such data could transform health systems and make it possible to take preventive measures rather than reacting after outbreaks become widespread. In February 2017 GSMA launched a new Big Data for Social Good initiative to leverage mobile operators' big data capabilities in addressing epidemics and humanitarian crises.[118] Initial trials of Big Data for Social Good for epidemics and environmental pollution are currently underway with Bharti Airtel in India, Telefónica in Brazil, and Telenor Group in Bangladesh, Myanmar and Thailand.

The United Nations (UN) Global Pulse Jakarta lab has used big data to tackle issues that closely align with DFAT's goals, including projects to build resilience, health, and food security.[119] LIRNEasia seeks to improve urban and transportation planning and policies in Sri Lanka by combining mobile network and electricity consumption data, satellite imagery, social media posts and closed-circuit television

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117 Wesolowski, A, Eagle, N, Tatem, AJ, Smith, DL, Noor, AM, Snow RW & Buckee, CO 2012, 'Quantifying the Impact of Human Mobility on Malaria', *Science*, Vol. 338, Issue 6104, pp. 267 – 270.

118 GSMA 2017, *GSMA Announces New Developments in Big Data for Social Good Initiative*, https://www.gsma.com/newsroom/press-release/gsma-announces-new-developments-big-data-social-good-initiative/, viewed on 28 December 2017.

119 United National Global Pulse, *Monitoring Social Response Before and After Natural Disasters with Data Analytics*, http://www.unglobalpulse.org/projects/monitoring-social-response-and-after-natural-disasters-data-analytics, viewed on 28 December 2017.

(CCTV) footage with administrative data and official statistics.[120]

Risks also come with using big data in development and developing countries more generally. Big data often involves digitising and automating data collection and can make staff and intermediate management redundant. The introduction of big data in Indian public sector organisations, such as electrical companies, for example, has led to data-collection staff lay-offs and inequalities between labour and management, as well as between middle and upper management.[121] Digital upskilling, and addressing associated loss or employment in an inclusive way, is essential when operating in the context of applied big data trends.

OPEN DATA

Open data is typically defined as data that can be freely accessed, used, modified, and shared by anyone. It is subject, at most, to a requirement to attribute and share alike. The definition implies that open data should be machine readable, accessible and reusable. Digital technology enables its production, publishing and access. Rather than being open or closed, data often sits on a continuum between the two poles and opening up data systems can be seen as a fluid process rather than a static one-off action. The Open Data Barometer is a tool the World Wide Web Foundation developed to show where governments sit on this continuum.[122]

Globally, the open data movement has focused on lobbying for open government data and many governments have opened data for access and use as a result. The Open Data Impact Map counts over 1,770 organisations in 96 countries that use open government data to add value in a diverse set of sectors including health care, energy and climate, agriculture, transportation and education.[123]

Governments in developing countries, including in the Indo-Pacific region, for example, the Philippines,[124] have begun to open up their data. However, an overwhelming majority of organisations using open data are in developed countries. Although the Indo-Pacific region counts 183 organisations, the majority are in developed countries: Australia, Japan, South Korea, New Zealand and Taiwan.[125] However, some countries in the Indo-Pacific region host open data organisations, including the Philippines (4), Indonesia (9), Cambodia (1), and PNG (1). NGOs have primarily implemented open data projects, to increase transparency and inclusivity in governance.

One of the main differences between big and open data is that in the case of raw big data – the same organisation that collects it generally turns it into actionable insight and rarely makes the raw data publicly available. In the case of open data, however, individuals or organisations that may not have been considered as users when the data was first generated turn it into information or end products. Open data can be reused and repurposed, so anyone accessing the data can use it to develop new platforms and tools, some of which may have development impacts. Besides increasing government transparency and accountability, open data empowers citizens and spurs innovation and economic development.

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120 Athuraliya CD 2017, 'Sensing Space with Big Data', in *LIRNEasia*, http://lirneasia.net/2017/05/big-data-igf-presentation-athuraliya/, viewed on 28 December 2017.

121 Heeks, R 2017, *A Structural Model and Manifesto for Data Justice for International Development*, Centre for Development Informatics, Manchester.

122 World Wide Web Foundation 2017, *Open Data Barometer*, http://opendatabarometer.org/?_year=2016&indicator=ODB, viewed on 28 December 2017.

123 Open Data Impact Map 2017, *Open Data Impact Map*, http://www.opendataimpactmap.org/index.html, viewed on 29 December 2017.

124 Philippine Statistics Authority 2017, *OpenSTAT*, http://openstat.psa.gov.ph/, viewed on 29 December 2017.

125 Center for Open Data Enterprise 2017, *Open Data Impact Map*, http://www.opendataimpactmap.org/eap.html, viewed on 29 December 2017.

CITIZEN-GENERATED DATA

Citizen-generated data refers to data that citizens actively and consciously produce and use to achieve a specific goal, rather than data and information they passively consume. It has also been defined as "data that people or their organisations produce to directly monitor, demand or drive change on issues that affect them".[126] Citizen-generated data in development includes participatory face to face methods such as community mapping. Digital technologies, namely mobile phones and Internet connectivity, are becoming increasingly ubiquitous. Moreover, open source software has proliferated so that it can be scaled quickly and tailored to fit specific contexts or situations. This has made it possible to crowdsource greater numbers of inputs from greater numbers of people and make data accessible to anyone online.

The principles behind digital citizen-generated data build on those of online crowdsourced content such as Wikipedia, which emphasise democratisation of content and data creation. Whereas statistical experts and governments have traditionally undertaken data collection and decided what data is required and how to collect it, citizen-generated data allows ordinary people to make those decisions. The first widely publicised used of citizen-generated data in development was in 2007 when Ushahidi used crowdsourced information to map post-election violence in Kenya. Compared to mainstream media, the crowdsourced platform covered a wider geographical area and a greater number of incidents, was more specific about incidents' location and nature, and was generally faster.[127] Since then, citizen-generated data presented in maps, including data shared via SMS messages, social media posts, emails and web apps, has been used to respond to various issues, including documenting human rights violations in Syria to support disaster response in the Philippines after typhoon Haiyan in 2013[128] and in Nepal after the earthquake in 2015.[129]

Citizen-generated data is particularly valuable when formal data on a given issue is non-existent, incomplete, out of date, or remains proprietary and inaccessible to the public. This is especially so when responding to emergencies (for example, natural disasters or episodes of political violence), which by their very nature make existing data less representative of the situation on the ground. Citizen-generated data has proved especially useful in disaster response, represented in crisis maps that help humanitarian actors get a better understanding of when, where and what kind of relief is needed. According to reinsurer Munich RE, between 2011 and 2015 there were 1,889 natural loss events in Asia and Oceania, nearly half of the total 3,927 events worldwide. Moreover, the region accounted for over 77 per cent of global fatalities from such events.[130] The potential for citizen-generated data to save lives after disasters is substantial.

Another way of incorporating citizen voices to improve development outcomes is by using SMS-based polling. UNICEF has developed U-Report, "a social messaging tool allowing anyone from any community, anywhere in the world to respond to polls and report issues".[131] UNICEF has used it in over 35 countries, including Indonesia, Myanmar, Nepal, Pakistan, PNG and Thailand. U-Report polls subscribers to

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126 Piovesan, F 2017, *Statistical Perspectives on Citizen Generated Data*, DataShift.

127 Meier, P 2008, 'Crisis Mapping Kenya's Election Violence', in *iRevolutions*, https://irevolutions.org/2008/10/23/mapping-kenyas-election-violence/, viewed on 29 December 2017.

128 Butler, D 2013, 'Crowdsourcing goes mainstream in typhoon response', in *Nature*, http://www.nature.com/news/crowdsourcing-goes-mainstream-in-typhoon-response-1.14186, viewed on 29 December 2017.

129 Parker, L 2015, 'How 'Crisis Mapping' Is Shaping Disaster Relief in Nepal', in *National Geographic*, http://news.nationalgeographic.com/2015/05/150501-nepal-crisis-mapping-disaster-relief-earthquake/, viewed on 29 December 2017.

130 Munich RE 2016, *NatCatSERVICE*, http://natcatservice.munichre.com/percentages/1?filter=eyJ5ZWFyRnJvbSI6MjAxMSwieWVhclRvIjoyMDE2LCJhcmVhSWRzIjpbNCwyNF19&type=1, viewed on 29 December 2017.

131 UReport 2017, *UReport*, https://ureport.in/, viewed on 29 December 2017.

the system, known as U-Reporters, on issues related to development including health, education, water and sanitation, and disease outbreaks. It maps results on the U-Report website, sharing them in near-real time with the general public and development organisations. Other organisations have developed more active SMS systems, allowing citizens to raise their own concerns rather than responding to polls with predefined responses. The Sentinel Project started Una Hakika in Kenya's Tana Delta region, where inaccurate information spread by word of mouth had previously led to ethnic violence.[132] The SMS-based platform allows citizens to report rumours and verify their truthfulness in near-real time, curbing further violence and contributing to stability. The organisation has recently partnered with initiatives in Myanmar to track violent episodes[133] and tackle misinformation and prevent violence.[134]

The biggest risk when using citizen generated data is its potential lack of representativeness. Poor people, women, rural inhabitants, ethnic minorities and other marginalised groups are less likely to have access to digital technologies. Using mobile phones or the Internet to garner insights about how development projects are functioning may not present a representative view of how marginalised people see such projects.

3.3 Software Innovations

BLOCKCHAIN

A blockchain is a digital ledger of transactions that is distributed, verified and monitored by multiple sources simultaneously. Traditionally, ledgers hosted by trusted third parties, such as banks and governments, have enabled and facilitated many vital functions in society, including validating ownership or transactions, or verifying that a given piece of information is true. These ledgers are generally centralised, opaque, alterable, subject to being hacked and slow. In contrast, a blockchain is distributed: all participants share its ownership.

Because it is distributed across millions of users, a blockchain has no single point of failure, making it especially difficult and economically unfeasible to hack. It is transparent, anyone can view or access the entire ledger, which is updated in near-real time, and it is immutable – transactions cannot be reversed. Moreover, like the Internet, blockchains are borderless, allowing very low cost transactions independent of where both parties are located.

Blockchains can disrupt just about every sector since any unit of value can be transacted on a blockchain, leading some to call it the "economic layer the Internet never had".[135] The first era of the Internet fostered a greater democratisation and decentralisation of knowledge, and the blockchain technology may extend this democratisation to transactions and value creation.

The Indo-Pacific region has begun experimenting heavily with the technology. Much of the experimentation has been pushed by big banks and big e-commerce companies such as AliBaba. But there have also been some pilots relevant to development. Examples include improving traceability of tuna throughout the supply chain in Indonesia to ensure it is sourced

[132] Una Hakika 2017, *Una Hakika*, https://www.unahakika.org/, viewed on 29 December 2017.
[133] The Sentinel Project 2017, *Burma*, https://thesentinelproject.org/burma-soc/, viewed on 29 December 2017.
[134] Boyd, D 2017, 'Peace and Technology in Myanmar's Royal City', in *The Sentinel Project*, https://thesentinelproject.org/2017/04/10/peace-and-technology-in-myanmars-royal-city/, viewed on 29 December 2017.
[135] Institute of Development Studies 2017, '*Blockchain for Development – Hope or Hype?*', *Rapid Response Briefing*, Issue 17.

ethically,[136] facilitating remittances to the Philippines,[137] providing identification for people living in remote areas in PNG,[138] and tracking aid in Pakistan.[139] In other regions blockchain is being used for international payments,[140] land registries,[141] smart-aid contracts[142] and decentralised peer to peer aid.[143] According to one expert, "if the country is willing to take it up, it doesn't require huge infrastructure. We can use the technology to address all kinds of regulatory issues, for example, the use of blockchain for trade finance."

ARTIFICIAL INTELLIGENCE & MACHINE LEARNING

Artificial intelligence, or AI, is the study of devices that perceive their environment and define courses of action independently to achieve their goals.[144] Machine learning is a subfield of AI in which machines learn how to complete a certain task without being explicitly programmed to do so.

Machine learning algorithms can identify patterns in observed data, build explanatory models and make predictions quicker[145] and with more accuracy than humans,[146] as well as provide the foundation for technologies like self-driving cars or speech recognition. The potential of machine learning for international development is wide ranging, and includes predicting poverty[147] and estimating unemployment rates through satellite images,[148] or helping smallholder farmers access credit.[149]

AI is likely to have a significant impact on the future of work in the region, as it is increasing the scope of tasks that can be automated. Jobs in developing countries are more susceptible to automation, but this threat is partially buffered by low wages and low technological diffusion.[150] However, it is expected that business processes that had previously been outsourced to the region could soon be automated, posing a threat to industries in the Indo-Pacific such as agriculture, manufacturing and call centres.[151] For example, the ILO recently estimated that 89 per cent of call-centre jobs in the Philippines are at risk of automation.[152]

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136 Hannam, K 2016, 'This Emerging Tech Company Has Put Asia's Tuna On The Blockchain', in *Forbes*, https://www.forbes.com/sites/keshiahannam/2016/09/30/this-emerging-tech-company-has-put-asias-tuna-on-the-blockchain/#47c80aa12649, viewed on 29 December 2017.

137 Abra 2017, *Abra*, https://www.abra.com/, viewed on 29 December 2017.

138 IDbox 2017, *IDbox*, http://www.idbox.io/about.html, viewed on 29 December 2017.

139 Disberse 2017, *The Future of Global Development Finance*, http://www.disberse.com/, viewed on 29 December 2017.

140 BitPesa 2017, *Move with Africa*, https://www.bitpesa.co/, viewed on 29 December 2017.

141 Shin, L 2017, 'The First Government To Secure Land Titles On The Bitcoin Blockchain Expands Project', in *Forbes*, https://www.forbes.com/sites/laurashin/2017/02/07/the-first-government-to-secure-land-titles-on-the-bitcoin-blockcha in-expands-project/#71c680774dcd, viewed on 29 December 2017.

142 Giveth 2017, *Giveth*, http://www.giveth.io/, viewed on 29 December 2017.

143 BitGive 2017, *BitGive: Vastly improving philanthropic impact withy blockchain technology*, https://www.bitgivefoundation.org/, viewed on 29 December 2017.

144 World Wide Web Foundation 2017, *Artificial Intelligence: The Road Ahead in Low and Middle-Income Countries*, World Wide Web Foundation, Washington.

145 IBM 2017, *IBM Research achieves record deep learning performance with new software technology*, https://www.ibm.com/blogs/research/2017/08/distributed-deep-learning/, viewed on 29 December 2017.

146 Stanford Medicine 2016, *Computers trounce pathologists in predicting lung cancer type, severity*, http://med.stanford.edu/news/all-news/2016/08/computers-trounce-pathologists-in-predicting-lung-cancer-severity.html, viewed on 29 December 2017.

147 Jean, M, Burke, M, Xie, M, Davis, WM, Lobell, DB & Ermon, S 2016, 'Combining satellite imagery and machine learning to predict poverty', *Science*, vol. 353, Issue 6301, pp. 790 – 794.

148 Gonzales, A 2017, 'Can new developments in machine learning and satellite imagery be used to estimate jobs?', in *World Bank Blog*, https://blogs.worldbank.org/jobs/can-new-developments-machine-learning-and-satellite-imagery-be-used-estimate-jobs, viewed on 29 December 2017.

149 FarmDrive 2017, *Alternative Credit Scoring for Smallholder Farmers*, https://www.farmdrive.co.ke/, viewed on 29 December 2017.

150 World Bank Group 2016, *World Development Report 2016: Digital Dividends*, World Bank, Washington.

151 The Economist 2016, 'Call centres: The end of the line', in *The Economist*, https://www.economist.com/news/international/21690041-call-centres-have-created-millions-good-jobs-emerging-world-technology-threatens, viewed on 29 December 2017.

152 Chang, J & Huynh, P 2016, *ASEAN in Transformation: The Future of Jobs at Risk of Automation, International Labour Organization, Geneva.*

3.4 Hardware Innovations

THE INTERNET OF THINGS

The Internet of Things (IoT) refers to the interconnection of physical objects embedded with low-cost sensors, actuators and communications technology. The IoT creates opportunities to directly integrate the physical world into computer-based systems, enabling connected objects to be sensed and coordinated remotely across existing network infrastructure, thanks to their capacity to send, receive and exchange data.

It is possible to attach sensors to items to track their location and condition; embed them in infrastructure to control their surroundings; include them in multi-functional gadgets such as smartphones; or integrate them into robots to support their movement and activities. From monitoring drones as they deliver vaccines across Vanuatu,[153] to measuring the humidity of the soil in Indian cornfields,[154] to tracking the output of water pumps in Bangladesh,[155] development actors can integrate the IoT into virtually any process.

IoT sensors generate data that, when aggregated and processed, can be a valuable resource for governments, businesses, and individuals. Analysis of IoT data can be carried out automatically and acted on in real time by autonomous systems. Such data can also be presented in the form of real-time dashboards to aid in making operational decisions. Finally, advanced analytics and deep learning processes can extract patterns from big data to support prediction and deeper understanding of complex problems.

The IoT promises to deliver social and economic benefits to emerging and developing economies: health care, manufacturing, agriculture, environmental monitoring, infrastructure and utilities management are sectors where impact will be most immediate and visible.[156] Smart cities are one of the most promising areas. IoT technologies could alleviate problems linked to pollution, traffic, flooding, and the challenges of providing government services such as solid waste management and electricity.[157]

Analysts expect countries in the Indo-Pacific region to lead the process of IoT adoption, driven by trends such as rapid urbanisation, increasing use of mobile devices and economic diversification from agriculture to other sectors.[158] However, many countries in the region have limited connectivity and technological literacy, uneven purchasing capacity and precarious basic infrastructure – such as access to electricity – which hamper the potential of IoT solutions. While much IoT innovation originates in and aims to satisfy the needs of developed countries, it is possible to adapt them for developing countries.[159]

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153 UNICEF 2017, *Vanuatu: Revolutionary technology for lifesaving vaccine deliveries*, http://unicefstories.org/2017/06/11/vanuatu-revolutionary-technology-for-lifesaving-vaccine-deliveries/, viewed on 29 December 2017.

154 TATA Consultancy Services 2016, *mKRISHI Research – Technology-enabled solutions address agricultural challenges*, https://www.youtube.com/watch?v=HKPLznEvzd4, viewed on 29 December 2017.

155 Purvis, K 2016, 'How do you solve a problem like a broken water pump?', in *The Guardian*, https://www.theguardian.com/global-development-professionals-network/2016/mar/22/how-do-you-solve-a-problem-like-a-broken-water-pump, viewed on 29 December 2017.

156 Biggs, P, Garrity, J, LaSalle, C & Polomska, A 2016, *Harnessing the Internet of Things for Global Development*, International Telecommunication Union, Geneva.

157 Industry Platform 2017, *Asia IoT Business Platform*, http://iotbusiness-platform.com/blog/asean-smart-cities-part-ii/, viewed on 29 December 2017.

158 Tan, J 2016, 'Internet of things gains momentum in Southeast Asia', in *ComputerWeekly.com*, http://www.computerweekly.com/news/450404190/Internet-of-things-gains-momentum-in-Southeast-Asia, viewed on 29 December 2017.

159 Biggs et al 2016.

Locally adapted frugal innovations tend to be simpler and more cost-effective,[160] using widespread technologies such as feature phones and text messaging to create business models that generate enormous value.[161] For example, IoT-supported pay-as-you-go financing schemes, which firms such as M-KOPA in Africa[162] or Kamworks in Cambodia[163] use to provide solar energy products to off-grid households, and are uniquely suited to unlock access to utility services for economically disadvantaged people.[164] In effect, they leapfrog traditional models of provision. IoT technologies such as SparkMeter, which the Australian Government funds through the Global Innovation Fund, use mesh wireless networks to create smart energy grids.[165]

Local and national governments – and public service providers in general – are progressively introducing better IoT-powered public services, frequently supported by development organisations. Countries are focusing digital and IoT strategies on distinct areas, such as smart cities, agriculture and connectivity. However, from a regional perspective, it is important to stimulate local innovation ecosystems and strengthen capacity to adapt and apply business models and technologies developed in other places.

Analysts at the Lawrence Berkeley National Lab have identified the ability to adapt IoT technologies for low-income populations as one of the technological breakthroughs required to drive global sustainable development.[166] However, most experimentation in the IoT for development (IoT4D) field is in small-scale projects driven by NGOs, social enterprises and academia.[167] They frequently use resources from innovation funds and challenges, such as the DFAT-funded MIT SOLVE Workforce of the Future challenge,[168] Frontier Innovators[169] or In.Code in Indonesia.[170]

The most pressing challenges to the IoT relate to technology, security, privacy, legal and regulatory issues, interoperability and standards, and organisational skills and capacities.[171] These issues could limit the IoT's rate of growth. However, current trends are mainly positive, and the rate of innovation is expected to accelerate as the IoT integrates newer technologies and capacities.

Mobile operators and technology companies are in the midst of standardizing and deploying Low Power Wide Area Networks (LPWAN), especially designed for IoT applications.[172] They are low cost, use low data rates, require long battery lives and often operate in remote and hard to reach locations. LPWANs will play an important role in connecting up the billions of new devices making up the IoT.[173]

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160 BRAC 2017, *Frugal Innovation Forum*, http://innovation.brac.net/fif2017/, viewed on 29 December 2017.

161 Phelan, D 2017, '8 best feature phones', in *The Independent*, http://www.independent.co.uk/extras/indybest/gadgets-tech/phones-accessories/best-feature-phones-nokia-3310-buy-uk-where-cheap-basic-for-festivals-camera-battery-life-a7755896.html, viewed on 29 December 2017.

162 M-KOPA 2015, *Affordable, clean energy: a pathway to new consumer choices*, M-KOPA.

163 GSMA Mobile for Development Utilities 2016, *Mobile for Development Utilities: Kamworks*, GSMA, London.

164 GSMA Mobile for Development Utilities 2016, *Mobile for Development Utilities. Unlocking access to utility services: The transformational value of mobile*, GSMA, London.

165 SparkMeter 2017, *SparkMeter*, http://www.sparkmeter.io/en/solution/, viewed on 29 December 2017.

166 Buluswar, S, Friedman, Z, Mehta, P, Mitra, S, Sathre, R 2014, *50 Breakthroughs: Critical scientific and technological advances needed for sustainable global development*, Institute for Globally Transformative Technologies, Berkeley.

167 Woodard, J, 2017, *Inventory of Digital Technologies for Resilience in Asia-Pacific*, fhi360.

168 MIT SOLVE 2017, *Youth, Skills and the Workforce of the Future*, https://solve.mit.edu/challenges/youth-skills-the-workforce-of-the-future, viewed on 29 December 2017.

169 InnovationXchange 2017, *Frontier Innovators*, http://www.frontierinnovators.org/home, viewed on 29 December 2017.

170 The Asia Foundation 2017, *In.CoDe: Indonesia's Competition for Civic Tech Apps*, http://asiafoundation.org/2017/07/12/code-indonesias-competition-civic-tech-apps/, viewed on 29 December 2017.

171 Ramalingam, B, Hernandez, K, Prieto Martin, P & Faith, B. 2016, *Ten Frontier Technologies for International Development*, Institute of Development Studies, Brighton.

172 GSMA, *Mobile IoT*, https://www.gsma.com/iot/mobile-iot-initiative/, viewed on 29 December 2017.

173 Purvis, M 2017, 'LPWA Will Enable 1 in 4 Industrial Wireless IoT Connections by 2022, Says ON World', in *PRWeb*, http://www.prweb.com/releases/2017/10/prweb14837857.htm, viewed on 29 December 2017.

SMART CITIES

The smart city is an idea and aspiration that has emerged alongside the increasing digitisation of the world. A smart city is one in which IT and other innovative technologies are leveraged to make the city function more effectively and efficiently. Most countries in the Indo-Pacific region are developing and urbanising quickly. Population growth and urbanisation are projected to add 2.5 billion people to the world's cities by 2050, with nearly 90 per cent of the increase coming in Asia and Africa.[174] In this context, cities provide an important environment for leveraging the potentially transformative power of technology and innovations.

The idea of smart cities was first articulated in developed countries and was born of an instrumental relationship between urban governments and large IT companies such as IBM and Cisco.[175] Similar to other aspects of technology-driven development, as the concept is applied to developing contexts it will be important to ensure that smart city transformations also serve to alleviate and address important development challenges such as poverty, inequality, environmental degradation, and the risks associated with climate change.

Donors and governments are increasingly acknowledging that technologies cannot solve complex social, administrative, and governance problems alone. A smart city must be one that goes beyond effectiveness and efficiency to incorporate inclusiveness, equity, and justice. This is important to address rising internal disparities between leading and lagging areas and deepening pockets of urban poverty, where residents in urban slums or informal settlements often lack security of tenure and access to basic infrastructure such as adequate water supply and sanitation.

Most countries in the Indo-Pacific region, including Australia, have explicit policies in place aiming to develop smart cities. Singapore is a global leader in the application of smart city technologies and structures. Similarly, the Association of Southeast Asian Nations (ASEAN) has implemented two major agendas – the Master Plan on ASEAN Connectivity (MPAC) 2025[176] and the ASEAN 2030 agendas[177] – aimed at strengthening multiple forms of connectivity both within and between ASEAN member states, which are attempting to put in place enabling conditions for smart city applications.

3D PRINTING

3D printing enables users to print physical objects using a variety of materials including plastics, metals, food and even living cells. Printed items can range from nano-sized objects to entire buildings. Whilst 3D printing has been around since the 1980s it has very recently begun to come of age and is often referred to as one of the cornerstones of the 4th industrial revolution. 3D printing may lead to a wholesale transformation of material production, supply chains and logistics processes by enabling local, flexible, efficient, and on-the-fly production of the supplies, parts and tools required for crucial tasks. The fields that are experimenting with this set of technologies are diverse and range from design and production of airplane engines,[178] mass

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[174] Smart Cities Dive 2017, *Is the Rapid Rate of Southeast Asia's Urbanization Sustainable?*, https://www.smartcitiesdive.com/ex/sustainablecitiescollective/rapid-rate-southeast-asias-urbanization-sustainable/1311792/, viewed on 29 December 2017.

[175] Deakin, M. ed., 2013. Smart cities: governing, modelling and analysing the transition. Routledge.

[176] Association of Southeast Asian Nations 2016, *Master Plan on ASEAN Connectivity 2025*, The ASEAN Secretariat, Jakarta.

[177] Association of Southeast Asian Nations 2016, *ASEAN to contribute to global 2030 agenda*, http://asean.org/asean-to-contribute-to-global-2030-agenda/, viewed on 30 December 2017.

[178] Moseman, A 2017, 'GE Made a Real 3D-Printed Plane Engine and Here's a Gorgeous Look at It', in *Popular Mechanics*, http://www.popularmechanics.com/flight/news/a27495/ge-3d-printed-aircraft-engine/, viewed on 29 December 2017.

production of consumer goods,[179] to medical goods and supplies in rural post-disaster settings,[180] and building entire homes.[181]

The remoteness of Pacific Island states makes it costly to ship to and their small populations mean they are unable to benefit from economies of scale, relying on smaller cargo ships. 3D printing may help overcome these barriers by decentralising production, cutting costs and time, creating local opportunities, and increasing the diversity of goods available. Countries in the Pacific region are some of the most vulnerable to climate change and natural disasters, making 3D printing especially valuable during disasters when existing infrastructure is often destroyed and roads are impassable. Despite this potential, there is little 3D printing activity in Pacific Island states. 3D Printing pilots in the Indo-Pacific region more generally include manufacturing customised aid supplies[182] and prosthetic hands and arms in Nepal.[183]

The cost and efficiency savings from producing goods closer to the end user in developed economies and replacing workers with machines may eventually outweigh the labour cost advantages that Asian manufacturing sectors heavily relied on in the past. In conjunction with AI, 3D printing could have serious consequences for economic growth and jobs in the Indo-Pacific region if adopted at an industrial scale.

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179 Vincent, J 2017, 'Adidas reveals the first 3D-printed shoe it'll mass-produce', in *The Verge*, https://www.theverge.com/2017/4/7/15216724/adidas-3d-printed-sneaker-futurecraft, viewed on 29 December 2017.

180 Field Ready 2017, *Field Ready*, https://www.fieldready.org/, viewed on 29 December 2017.

181 Molloy, M 2017, 'This incredibly cheap house was 3D printed in just 24 hours', in *The Telegraph*, http://www.telegraph.co.uk/technology/2017/03/03/incredibly-cheap-house-3d-printed-just-24-hours/, viewed on 29 December 2017.

182 Field Ready 2017, *Nepal*, https://www.fieldready.org/nepal, viewed on 29 December 2017.

183 Disaster Hack 2017, *3D-Printing*, http://www.disasterhack.org/3dprinting/, viewed on 29 December 2017.

4 – Opportunities for Action

The regional overview, and associated implications for rates of digital adoption, present clear opportunities to optimise the use of technology for development outcomes in the Indo-Pacific region. The actions outlined in this section complement those detailed in Australia's International Cyber Engagement Strategy, and provide opportunities for implementers to broaden their influence on the digital development landscape in the Indo-Pacific region.

4.1 Enhance inclusion through inclusive programming and improved infrastructure

A constraining factor to transformative technology uptake in the Indo-Pacific, as it is globally, is inequality of access compounded by gender inequality and marginalisation of vulnerable groups. Two approaches are required to effectively enhance inclusion in the Indo-Pacific: (1) gender responsive and inclusive programming, and (2) improved infrastructure to broaden access to reliable and affordable communications networks in the Pacific Island States and other rural and mountainous locations. Meaningful application of these approaches will not just connect women and other marginalised groups to technology, but empower them with it, making sure they are equally able to reap digital dividends in work, society and the family.

Existing geographic, social and economic inequalities are amplified by marginalisation and exclusion from the global information society and knowledge economy. Globally, even when active users of technology and social media, women are often stigmatised and attacked as users. As developers and coders, women often struggle to develop businesses and careers in a sector that is overwhelmingly populated by men and which provides limited access to support groups of peers and accessible professional organisations. New forms of violence against women are emerging, as well as new protective measures, enabled by technology.

Addressing gender and other inequalities could have a significant positive economic impact. A recent World Bank report, Pacific Possible, suggests that growth in information communication and technology (ICT) penetration in the region could trigger productivity gains of $US 4 billion by 2040.[184] The same report recommended a range of approaches

[184] World Bank, 2017, *Pacific Possible: Long-term Economic Opportunities and Challenges for Pacific Island Countries*, World Bank Washington, DC.

including mobilisation of public and private investment to bring increased and more affordable international bandwidth for Papua New Guinea, Kiribati and Tuvalu, and regulatory reforms addressing issues such as radio spectrum management.

Gender responsive and inclusive programming requires moving beyond mere inclusion as a measurement of success, to a more meaningful use of technology by women and marginalised groups. It requires understanding for example that women and men will use technology differently, that there are different risks and opportunities for men and women in the use of technology, and that to be inclusive, technology responses should seek to avoid reinforcing unequal power relations. This approach must also be applied to people with a disability, the elderly, and other marginalised groups.

Such programming requires the involvement of women and marginalised groups in design, implementation and evaluation, beginning with an analysis of the different uses and experiences of technology by various groups. It is important to ask each group what they want from technology, how technology can play a positive role in their lives, identify and mitigate any risks to their safety and leverage opportunities to use the technology as a protective measure. Implementation must be continually monitored to identify and address any negative impacts that arise unexpectedly.

More specific opportunities to strengthen gender responsive and inclusive programming include developing digital literacy activities that equip women and marginalised users to navigate the digital services they use once connected. A definition of digital literacy that isn't just about how to use digital tools, but how to safely explore and inhabit the digital societies they contain, will help protect users and maximise impact. Further, digital development programs should ensure that all outputs, both digital and physical, meet accessibility standards for people with a disability.

In strengthening access to digital financial services, develop activities that promote the shift from informal cash economies to formalised digital financial products for women and marginalised groups based on research and analysis establishing each group's different use of technology and their needs. Learn from previous programs, such as those developed by Women's World Banking, which bring digital financial service designers together with gender experts to build better products for women.[185]

In digital identity, women will often bear the burden of registration for the family where identity is linked to social payment programs, and yet often have identity artefacts withheld from them when they have the potential to empower them.[186] Understanding women's experiences in registering with and using digital identity systems is crucial, and needs to be a consideration in any digital identity system design.

For resources supporting digital development practitioners to integrate established best practices into technology-enabled programs more broadly, refer to the Principles for Digital Development and associated guidelines.[187]

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[185] Women's World Banking 2017, 'Designing better digital financial services for women: Lessons in behavioral design', https://www.womensworldbanking.org/news/blog/designing-better-digital-financial-services-women-lessons-behavioral-design/, viewed on 28 December 2017.

[186] Bailur, S 2017, 'Essay V5: There are persistent tensions around gender and identity', in *Identities*, https://www.identitiesproject.com/report/essay-v5/, viewed on 28 December 2017.

[187] Digital Impact Alliance 2017, 'Principles for Digital Development – Resources & Expertise for the Digital Principles.' https://digitalprinciples.org/, viewed on 28 December 2017.

4.2 Stimulate innovation in development-enabling technologies

Champion the use and adaptation of new technologies to specific regional, sub-regional and national contexts; supporting entrepreneurs to do so, and strengthening the digital development ecosystem including through civil society, universities, data policy hubs, and traditional and non-traditional media. Increase awareness of exciting digital development innovations across the region to help strengthen opportunities for technology transfer and for contextualised replication in other geographies.

It is equally important to build networks, entrepreneurial ecosystems and processes that effectively support entrepreneurs and innovators in order to embed the application and sustainability of technological innovation. Cross-pollination between technology and innovation hubs in the region could be strengthened by supporting the growth of dynamic entrepreneurship ecosystems, helping improve the agility of local start-ups, and investing in emerging technologies such as Internet of Things, Robotics, 3D printing, autonomous vehicles, 5G networks, virtual and augmented reality and others.

4.3 Increase efficiencies through catalytic investment in capacities

Improve digital literacy, skills development, and human capacity-building to help realise the development potential of digital technologies, with a specific attention paid to Science, Technology, Engineering and Maths (STEM) education for women and girls. The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) flagship report on *Harnessing Science, Technology and Innovation for Inclusive and Sustainable Development in Asia and the Pacific* notes contradictions in the landscape. The region is home to some of the most dynamic, pioneering and innovative countries in the world, but, at the same time, to some of the most technologically deprived. The report recommends the development of digital and innovation skills, and nurturing problem solvers as a means to "generate and make fit for purpose all available human capital through the stages of economic and social disruption that often accompany new technologies or innovative processes."[188]

Involve universities, software companies and training providers in the design and delivery of online and offline capacity-building across the Indo-Pacific region. Digital literacy and skills development are essential 'analogue complements' of digital development. Capacity development requires a medium-term perspective, a person-led approach and operations at the sub-regional-to-local levels. Building capacity is about more than training and there is opportunity to convene and weave networks of knowledge providers, academic communities and thought leaders to stimulate the lesson-learning and knowledge sharing.

[188] United Nations Economic and Social Commission for Asia and the Pacific 2016, *Harnessing Science, Technology and Innovation for Inclusive and Sustainable Development in Asia and the* Pacific, United Nations, Bangkok.

4.4 Support a free, open and secure Internet

Additional considerations are important to ensure technology for development interventions do not inadvertently exacerbate or create new social vulnerabilities in the region. In particular, respect for and protection of human rights online, and cyber security.

Increased connectivity and access to the Internet can also increase the possibility for misuse of the Internet to restrict human rights and opportunities for democratic participation. To guard against this, respect for and protection of human rights online must continue to be included at the forefront of development assistance programs that feature digital technology components.

While greater connectivity has the potential to facilitate sustainable and inclusive development, it also brings new threats. Poor cyber security practices and low cybercrime awareness can undermine trust in cyberspace, reducing the dividends of digital technologies. Conversely, trust in the online environment sustains and extends the development-enabling capacity of digital technologies.

Aid projects need to take into account the long-term security and resilience of technologies in order to support the safety and privacy of users and build trust in online systems. Technologies that are known to be resilient to threats, and that are trusted by users, will have greater impact on development outcomes.

The *International Cyber Engagement Strategy* foreshadows a Guidance Note on human rights online and cyber security.

POSSIBLE APPROACH – ESSENTIAL DIGITAL BUILDING BLOCKS

	Connectivity	Financial Services	Digital Identity
Scale Leaders	■ No need for intervention on infrastructure. ■ Promote affordability, digital literacy, gender-balance for access and openness.	■ Support programmes to move beyond person-to-person (P2P) payments into new financial services areas such as credit, insurance and savings. ■ Promote gender-balance for access to digital financial services.	■ Where government identification (ID) programs exist, learn and support adoption. ■ Work with private sector to see where they can co-operate with distribution and usage of government ID.
Fast Developers	■ Support and scale innovative business models that reach the unconnected. ■ Promote affordability, digital literacy, gender-balance for access and openness.	■ Encourage digitisation of remittance corridors for P2P payments to drive adoptions, and build usage of savings products. ■ Promote gender-balance for access to digital financial services.	■ Choose use case such as payment Know Your Customer (KYC) to build common ID service infrastructure with government.
Isolated Islands	■ Invest in research for new technologies to connect remote regions and support connectivity pilots. ■ Promote affordability, digital literacy, gender-balance for access and openness.	■ Work with government to stimulate digital payments adoption via digitisation of social payment programmes, bill payments. ■ Encourage digitisation of remittance corridors for P2P payments to drive adoptions. ■ Promote gender-balance for access to digital financial services.	■ Ensure analogue complements are in place to facilitate formal identity for all. ■ Consider digital and financial inclusion first, such as identity for birth registration and building infrastructure on social payment programs.

POSSIBLE APPROACH – EMERGING TECHNOLOGY OPPORTUNITIES

	Data Innovations	Software Innovations	Hardware Innovations
Scale Leaders	■ Where usage of digital financial services is widespread understand data better via programmes such as Shaping Inclusive Finance Transformations Program (SHIFT), which aims to build financial service providers' big data capacities to improve financial inclusion.[189]	■ Understand where blockchain technologies can provide new opportunities in digital financial services, adding more sophistication to existing products and democratising platforms.	■ Where high-levels of Internet penetration and usage are present in urban areas, consider supporting smart city strategies to make urban living more efficient and sustainable.
Fast Developers	■ DFAT-funded projects include mClinica, which uses big data to improve availability and affordability of essential medicines in Southeast Asia.[190] ■ Collaboration with data for development initiatives to target local challenges	■ Understand where artificial intelligence (AI) combined with emerging volumes of data from users can provide learning for credit scoring, behavioural understanding and other projects.	■ Consider basic IoT strategies such as those supported by the GSMA M4D Utilities program to spread better availability of basic utilities.
Isolated Islands	■ Understand where data capture can make the most of scarce resources often spread over vast distance to improve targeting and meeting needs – mHealth in particular.	■ Support natural language processing and other natural language projects in local languages, to support voice interfaces and easier accessibility to Internet services for low-income, low-literacy users.	■ Support programs such as the Pacific Drone Imagery Dashboard project, which aims to build an open source system where ultra-high resolution imagery from aerial drones can be accessed and shared during disasters.[191]

[189] UNCDF 2017, *SHIFT: Shaping Inclusive Financial Transformations*, http://shift.uncdf.org/, viewed on 1 January 2018.
[190] mClinica 2017, *Connecting Pharmacies, Transforming Global Health*, http://www.mclinica.com/, viewed on 1 January 2018.
[191] Global Innovation Exchange 2017, *Pacific Drone Imagery Dashboard (PacDID)*, https://www.globalinnovationexchange.org/innovations/pacific-drone-imagery-dashboard-pacdid, viewed on 1 January 2018.