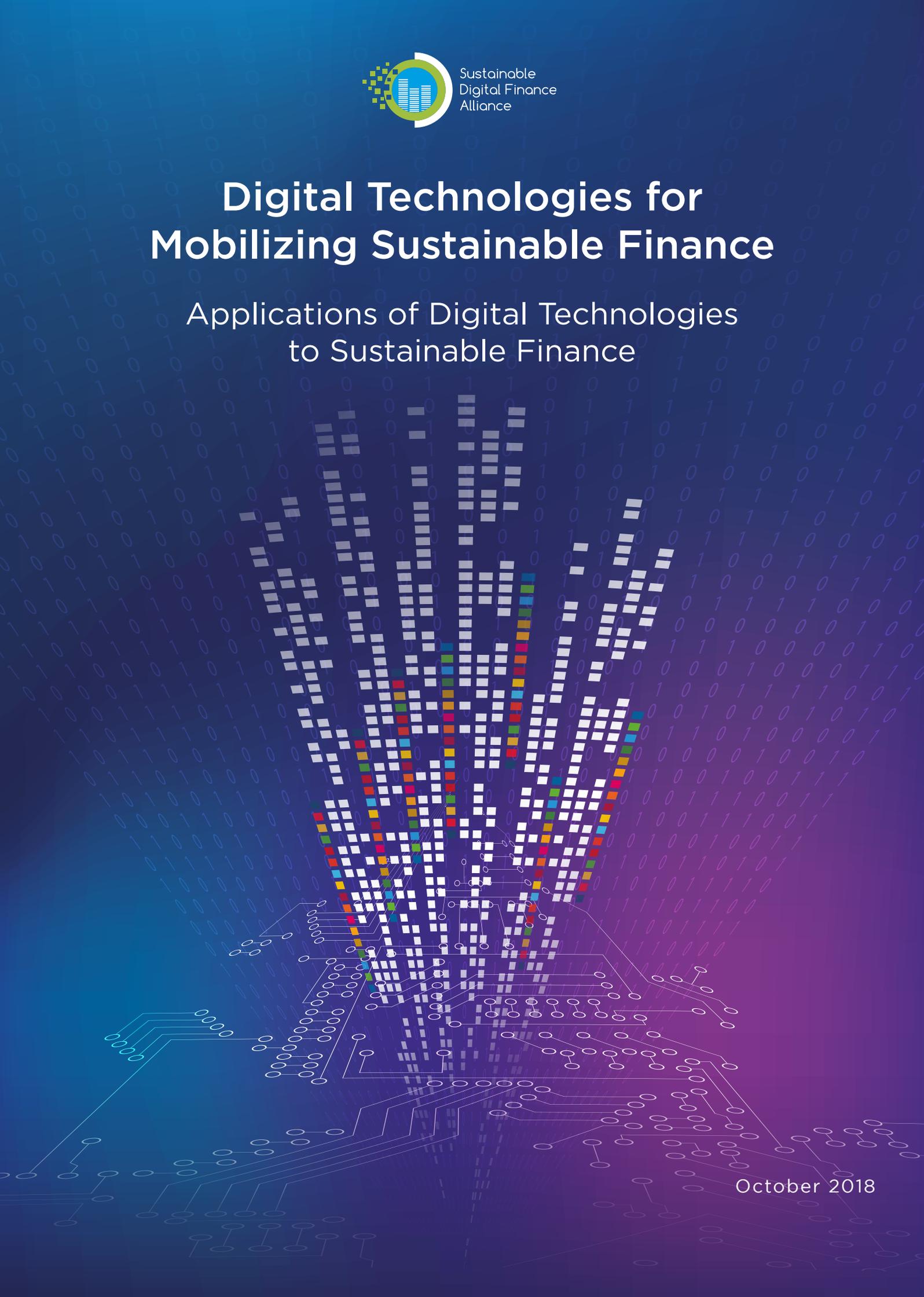


Digital Technologies for Mobilizing Sustainable Finance

Applications of Digital Technologies
to Sustainable Finance



October 2018

The Sustainable Digital Finance Alliance

The Sustainable Digital Finance Alliance has been founded by UN Environment and Ant Financial Services to address the potential for fintech-powered business innovations to reshape the financial system in ways that better align it with the needs of sustainable development. The Alliance's Advisory Board is co-chaired by Erik Solheim (Executive Director, UN Environment) and Eric Jing (CEO, Ant Financial Services) and comprises of innovative financial and sustainable development institutions committed to using digital technology to advance sustainable finance, including Piyush Gupta (CEO, DBS Group); André Hoffman (President, MAVA Foundation); Nick Hughes (Co-founder, M-KOPA); Caio Koch-Weser (Chair, European Climate Foundation); Rachel Kyte (CEO, Sustainable Energy for All); Philippe Le Houérou (CEO, IFC); Ma Jun (Director, Center for Finance & Development, Tsinghua), Phumzile Mlambo-Ngcuka (Executive Director, UN Women), Patrick Njoroge (Governor, Central Bank of Kenya); Henry Paulson (Chairman, Paulson Institute, former US Treasury Secretary); Alex Pentland (co-founder, MIT Media Labs); and Vijay Sharma (CEO, PayTM). The Alliance draws in allies from across the worlds of environment, development and finance, who, through their expertise, insights and networks can contribute to collaborative actions with timely and scaled potential. Building on the work of the UN Environment Inquiry published in 2016, *Fintech and Sustainable Development: Assessing the Implications*, the Alliance published its first paper *Scaling Citizen Action on Climate – ANT Financial's Efforts Towards a Digital Finance Solution* in May 2017.

More information is available at: info@sustainabledigitalfinance.org and www.sustainabledigitalfinance.org.

About this report

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Comments are welcome and should be sent to simon.zadek@un.org.

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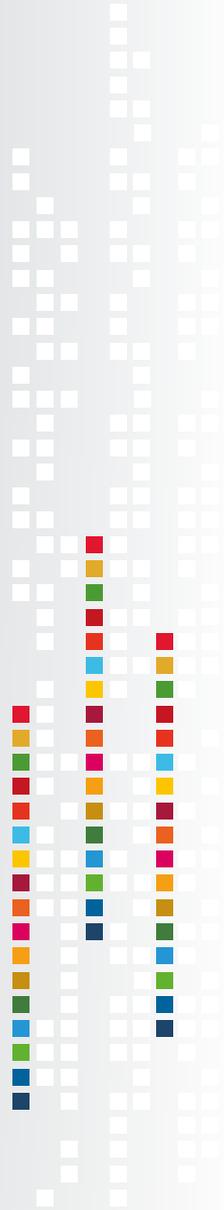
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ACRONYMS AND ABBREVIATIONS

AFIN	ASEAN Financial Innovation Network
AI	Artificial intelligence
API	Application programming interface
ASEAN	Association of Southeast Asian Nations
DLT	Distributed ledger technology
ETF	Exchange-traded funds
EU	European Union
EUR	Euro
FDI	Foreign direct investment
FSB	Financial Stability Board
GDP	Gross domestic product
GFSG	G20 Green Finance Study Group
GPFI	Global Partnership for Financial Inclusion
ICT	Information and communications technology
IFC	International Finance Corporation
MLAI	Machine learning and artificial intelligence
MSMEs	Micro, small and medium-sized enterprises
OECD	Organisation for Economic Co-operation and Development
P2P	Peer-to-peer
PAED	Publicly available environmental data
PE	Private equity
RMB	Chinese renminbi
SDGs	Sustainable Development Goals
SFSG	G20 Sustainable Finance Study Group
SMEs	Small and medium-sized enterprises
UK	United Kingdom
US	United States
US\$	United States dollar
VC	Venture capital
WEF	World Economic Forum



Executive Summary

Financing sustainable development and ensuring a resilient financial system are key current global challenges.

However, a number of barriers limit the mobilization of such finance at scale. For example, the lack of disclosure of environmental and social information creates information asymmetries and increases search costs for sustainable investments. Similarly, investors face difficulties in fully identifying, assessing and pricing risks associated with unsustainable investments as well as upside opportunities.

Digital finance, which includes big data, artificial intelligence (AI), mobile platforms, blockchain, and the Internet of things (IoT), is demonstrating its ability to address these barriers and promote sustainable, inclusive economic growth.

AI alone could lift global GDP by an estimated US\$15-20 trillion by 2030.¹ At the same time, technology advancements have not benefitted all equally, and the unintended consequences from such advancements have contributed to some of the most pressing environmental and development challenges today. Indeed, while the financial system has been at the forefront of adopting new technologies, its application of digital finance to sustainable finance is limited, and the impact of digital finance on scaling sustainable investments is far from certain. This creates opportunities for international cooperation and

policy-makers to address potential market failures, cross-border issues and common risks, better enabling digital finance to increase financial flows towards sustainable and inclusive investments. The G20 has recognized the importance of these developments for the financial system and its relationship with sustainable development in the real economy. Through its Sustainable Finance Study Group (SMSG), it is exploring opportunities to better leverage digital technologies for financing sustainable development, as well as the challenges that limit the effective use of digital technologies for this purpose, and how they might be overcome, particularly across capital markets, private equity and venture capital (PE/VC).

Digital finance makes large amounts of data available more quickly at lower costs, increasing transparency and access to information related to sustainable investments. It also promotes greater inclusion and innovation, increasing opportunities for citizen participation in the financial value chain and unlocking new sustainable business models.

Digital finance automates and makes large amounts of data available at high speed and low costs, which increases opportunities for more sustainable lending and investments in sustainable assets through greater information and transparency. This reduces search costs for information related to environmental, social and financial impacts and risks, improves

measuring, validating and tracking the ‘greenness’ of investments, and facilitates regulatory compliance. Digital finance also unlocks greater inclusion and innovation. It incentivizes citizens to direct financial resources towards more sustainable consumption choices, and unlocks new sources of finance, both ‘bottom-up’ and by better matching investors with sustainable investment opportunities. The interaction between innovations in digital finance and the real economy creates new business models that make investment in sustainable sectors commercially viable. Ultimately, these benefits enable the financial sector to interact more closely with the real economy and better align financial flows with the Sustainable Development Goals (SDGs).

In relation to the SDGs, linking specific sustainable digital finance practices and evidence of its impact, demonstrates that digital finance is contributing to achieving 13 out of 17 SDGs.

Mobile technology, followed by machine learning and artificial intelligence (MLAI) and big data are most prevalent, particularly related to unlocking new sources of sustainable finance and innovations in the financial and real economy. Further research is needed to assess the potential of current and emerging digital technologies with respect to achieving the SDGs and to measure impact beyond practices related to financial inclusion.

However, a mapping of sustainable digital finance practice across G20 members and the private sector reveal that the ‘data power’ of digital finance is under-leveraged

by the financial sector; that its ‘innovation power’ is small scale; and that it creates economic, social and environmental unintended consequences. Under-leveraged ‘data power’ raises the question about how digital finance technologies can be more widely mainstreamed by the financial sector to better integrate sustainability considerations into investment decision-making. Small-scale ‘innovation power’ raises the question about how the real economy can better use digital finance to drive innovations that make investments in sustainable business models, sectors and outcomes more viable at scale. Finally, while digital finance enables greater opportunities for boosting the positive impacts of sustainable finance, it blurs the line between sectors and stakeholder groups and creates a range of possible economic, social and environmental unintended consequences. If not appropriately managed, such consequences could jeopardize targeted impacts. The benefits as well as these implications are summarized in Figure 1.

Underlying these three implications are both generic challenges and specific challenges related to sustainable digital finance. The key challenges that are not unique to sustainable finance include weak digital infrastructure, as well as the high costs, risks and limited robustness of newer technologies. The challenges that are related specifically to leveraging the full potential of digital finance to mobilize sustainable finance include a limited understanding and awareness of sustainable digital finance, silos between stakeholder groups, little international

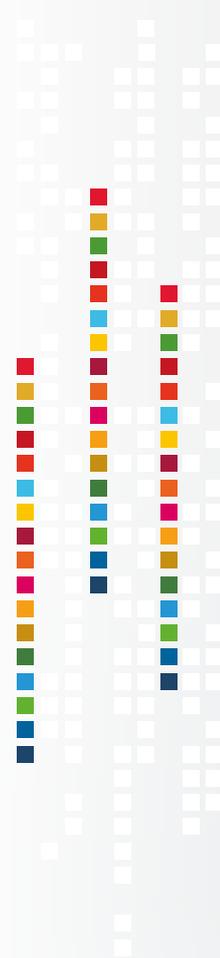
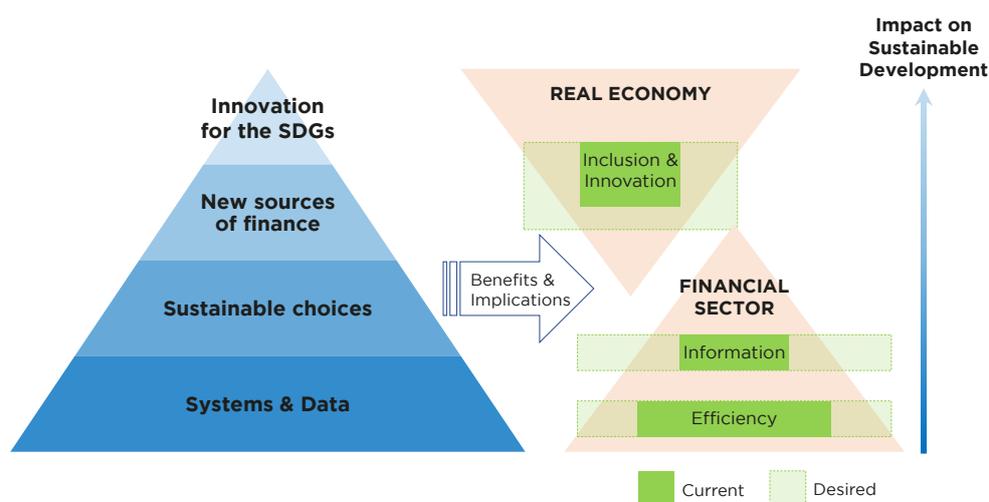


FIGURE 1: IMPLICATIONS OF DIGITAL FINANCE FOR SUSTAINABLE DEVELOPMENT



cooperation on the cross-border risks and opportunities, limited availability, value and use of sustainability-related data for financial decision-making, and nascent business models limiting access to large-scale investments. Leveraging the full potential of digital finance to enhance the mobilization of sustainable finance requires action by multiple actors across these challenges.

At the same time, new opportunities are emerging to address underlying challenges.

Digital finance is blurring the line between sectors and stakeholder groups, creating a need to redefine these borders in a certain capacity. Innovative multiparty engagement platforms are emerging at the national and international levels, allowing stakeholders to coordinate, sequence and measure the appropriate new system-wide protocols and regulations across a network of institutions and practice; as well as to share best practices, experiences, cost-benefit analysis and to consider unintended consequences of implementation.

These opportunities suggest specific actions that could be undertaken at the national, regional and international levels to concretely address challenges and better leverage the power of digital technologies for sustainable finance.

Comprehensive research by governments, international organizations and think tanks would help to raise awareness about the potential, opportunities and risks of the application of digital technologies to sustainable finance in specific areas, including with respect to achievement of the SDGs. At the national and regional levels, establishing multi-stakeholder platforms that bring together policymakers, financial sector players, sustainability actors and fintech communities, could act as centres of gravity for convening and engaging specifically on the sustainability elements of digital finance. Similarly, in terms of international collaboration, continuing the momentum created by the G20 SFSG on the topic of digital technologies and sustainable finance would be helpful in terms of moving the sustainable digital finance agenda forward. Actions to encourage

investment in digital technologies that advance sustainable finance are also important. Possible actions include: integrating sustainability elements into the existing fintech ecosystem; improving the visibility and the transparency of new sustainable digital finance solutions; defining the requirements to scale innovative pilots using blockchain and IoT; developing more standardized tools and

instruments for translating financial purchases data into environmental data; creating new sustainable financial products that are easily accessible online and through mobile applications; scaling virtual technology platforms that bring together sustainable assets and investors; and fostering close interactions between innovative sustainable digital finance solutions and regulators/supervisors.





Introduction

One of the key challenges faced by the global financial system today is to mobilize private capital to support sustainable growth and a stable financial system. In 2016 and 2017, the G20 Green Finance Study Group (GFSG) identified throughout its work various barriers to scaling and deploying sustainable finance. These include information asymmetries; limited analytical capabilities; maturity mismatches; and difficulties investors face in fully identifying,

assessing and pricing risks associated with unsustainable investments as well as upside opportunities (see Box 1).²

Digitalization, specifically its nexus with finance ('digital finance'), includes a broad range of technological developments such as big data, artificial intelligence (AI), mobile platforms, blockchain, and the Internet of things (IoT). Digitalization is not new to the financial system. Over the past

BOX 1: BARRIERS AND CONSTRAINTS TO ALIGNING AND SCALING SUSTAINABLE FINANCE

The G20, through the Green Finance Study Group in 2016 and the Sustainable Finance Study Group in 2018, outlines a number of barriers and constraints to aligning and scaling sustainable finance.³

- *Lack of internalizing environmental and social externalities:* Externalities can be positive for green and social investments as their benefits accrue to third parties, and negative when investments inflict harm on third parties. A lack of internalization of these externalities distorts the risk/return profile of such investments, resulting in the underinvestment in more sustainable activities.
- *Maturity misalignment:* Such misalignment arises due to inadequate supply of long-term funding relative to the demand for funding by long-term projects. This problem is particularly acute for sustainable investments that deliver their financial and sustainable benefits over longer periods of time, and that tend to have higher upfront costs.
- *Lack of information and information asymmetry:* Assessing certain sustainable development outcomes is difficult due to the lack of definitions, information disclosure and specific analytical capacity in the financial industry. The lack of consistent and reliable 'labelling' of sustainable assets also constitutes a barrier to sustainable investment.
- *Insufficient sustainability-related analytical capabilities:* Financial institutions are in the early stages of developing methodologies and tools to identify and assess financial risks associated with sustainable investments. This may lead to an "underestimation of the risks of 'brown' investments and overestimation of the risk profile of green investment opportunities".⁴

two decades, digital systems and automation have significantly increased efficiencies across the financial system. Today, digital finance is increasing demonstrating its ability to overcome key barriers to advancing finance for inclusive, sustainable development. PwC (2017) estimates that AI alone could lift global GDP by US\$15-20 trillion by 2030,⁵ while McKinsey (2016) estimates that digital finance could boost the GDP of emerging economies by US\$3.7 trillion by 2025, translating into GDP growth in India, Brazil, Mexico and China of almost 12%, 5.5%, 5% and 4.2% respectively.⁶

At the core of digital finance is its ability to make the availability, processing and analysis of larger amounts of complex data cheaper, faster and more accurate. This reduces the costs of obtaining timely, material information relevant to sustainability impacts and investments' financial risks; increases transparency; and supports public institutions to more effectively track the regulatory aspects of sustainable development. Digital technologies raise citizen awareness about the environmental and social implications of consumption and investment patterns, which incentivizes more sustainable behavioural choices. In addition to increasing 'financial inclusion' by enabling modern financial services to be more widely accessed and utilized, an angle that is dealt with under the Global Partnership for Financial Inclusion (GPFI),⁷ digital finance unlocks new sources of finance, both 'bottom-up' and by 'matching' investors with sustainable investment opportunities. There are also

a growing number of digital applications that mobilize and deploy capital for sustainable technologies and business models with great potential for improving the environment, as well as boosting economic growth and job opportunities.

These examples suggest significant potential for digital developments in advancing the mobilization deployment of sustainable finance. Research by the World Economic Forum (WEF), international organizations and national think tanks also highlight that deliberate innovation in financial services will exert continuous pressure shaping their long-term structure, business models and customer behaviour.⁸ While some aspects of the actual and potential impact of digital innovations on sustainable finance have received attention, notably how digital technologies enables financial inclusion, little work however has been advanced to date on possible challenges, opportunities and risks to advancing sustainable finance through the more effective use of digital finance.

The G20 has recognized the importance of these developments for the financial system and its relationship with the real economy, notably through the thematic focus of the German Presidency in 2017 and its continuation into Argentina's Presidency in 2018. In 2018, under Argentina's Presidency, the G20 Sustainable Finance Study Group 'looked to understand (i) the creation of sustainable assets for capital markets; (ii) the deployment of private equity and venture capital (PE/VC) to sustainable investments; and (iii)



applications of digital technologies to sustainable finance, particularly across capital markets, and private equity and venture capital.

This report summarizes research findings in response to this third research question. It describes the relevance of digital finance within the context of sustainable finance, the consequential G20 role, and the SDGs. It provides a framework to highlight practices across G20 members and the private sector in advancing technological solutions that support sustainable finance, notably across capital markets, private equity and venture capital. It identifies the key implications, as well as possible unintended consequences and challenges that

should be appropriately addressed. It also draws out emerging opportunities to better leverage digital technologies for financing sustainable development. The report is based on a mapping of practices across G20 members and the private sector, that highlight more efficient mobilization and deployment of capital for sustainable investments through the use of digital finance. Since current volatilities in the crypto-assets market are creating high levels of uncertainty, this report – which aims at teasing out common implications – does not cover crypto-assets. Further research is needed to fully unpack the risks and opportunities in this area.





01

RELEVANCE OF DIGITAL FINANCE IN THE CONTEXT OF SUSTAINABLE FINANCE AND THE G20

Today, the “trail of our digital exhaust is incomprehensibly vast. The world’s annual data generation is estimated to be doubling every year, and the overall size will reach 44 zettabytes (that’s trillions of gigabytes) by 2020”.⁹ Data has become a financial asset, with inherent cross-border properties and implications. Global mobile connections could reach 8.9 billion, a penetration rate of 114% within three years and the number of internet users has more than tripled in a decade, reaching 3.2 billion in 2015.¹⁰ The financial system has indeed been at the forefront of adopting new technologies,¹¹ with the scale and impact of digital finance reaching across all functions of the financial system (see Box 2).

At the same time, while technology has driven global economic growth, its unintended consequences have contributed to some of the most pressing environmental and sustainable challenges today.¹⁶ Similarly, the World Bank in its 2016 World Development Report highlighted that digital dividends – the broader development benefits from using technologies – have lagged behind, with uneven overall impact and a growing gender digital divide.¹⁷ The application of digital technologies by the financial sector to sustainable finance is also more limited. Hence, while digital finance has the potential to enhance the mobilization of finance for more inclusive, sustainable, economic development, this

BOX 2: FACTS AND FIGURES FROM INTERNATIONAL ORGANIZATIONS AND RESEARCH INSTITUTES: THE SCALE AND IMPACT OF DIGITAL FINANCE

- Digital transactions are up to 90 per cent cheaper to process than traditional transactions.¹²
- Digital finance can add US\$4.2 trillion in new deposits and US\$2.1 trillion in new credit.¹³
- Digital financial services can turn 1.6 billion of the 2 billion unbanked people into formal financial customers by 2025. That, in turn, would add US\$4.2 trillion to the balance sheets of providers, 95 million additional jobs and US\$3.7 trillion added to the GDP of emerging economies.¹⁴
- From 2011 to 2015, the number of mobile money subscribers worldwide grew from 60 million to over 400 million.¹⁵

outcome is uncertain. This suggests a possible role for policymakers and international cooperation to address potential market failures, cross-border issues and common risks to better harness

the opportunities created by digital finance to increase financial flows towards sustainable and inclusive investments. Box 3 offers working definitions of terms related to digital and sustainable finance.

BOX 3: DEFINITIONS

Digital finance

While there is no single agreed definition, the term digital finance is used by a broad range of international and national institutions, as well as the private sector to encompass a broad range of new financial products, businesses, software, and new forms of digitally enabled customer communication and interaction.¹⁸ International organizations and the private sector have also provided the following definitions of digital finance:

- International Telecommunication Union (2016): Digital financial services are an ecosystem consisting of users (consumers, businesses, government agencies and non-profit groups) who have needs for digital and interoperable financial products and services; the providers (banks, other licensed financial institutions, and non-banks) who supply those products and services through digital means; the financial, technical, and other infrastructures that make them possible; and the governmental policies, laws and regulations which enable them to be delivered in an accessible, affordable, and safe manner.¹⁹
- OECD (2017): Digital financial services can incorporate any financial operation using digital technology, including electronic money, mobile financial services, online financial services, iteller solutions, and branchless banking.²⁰
- World Bank (2016): Digital finance refers to the impact that the Internet and related digital technologies have on the financial sector.²¹
- McKinsey (2016): Digital finance refers to financial services delivered over digital infrastructure – including mobile and internet – with low use of cash and traditional bank branches. Mobile phones, computers, or cards used over point-of-sale (POS) devices connect individuals and businesses to a digitized national payments infrastructure, enabling seamless transactions across all parties.²²

Similarly, while there is no universally accepted definition of the term “**fintech**” (which stands for financial technology), Kawai (2016), Secretary-General of the International Association of Insurance Supervisors, a member organization of the Financial Stability Board (FSB), offers a working definition of fintech as a “technologically enabled financial innovation that gives rise to new business models, applications, processes and products. These could have a material effect on financial markets and institutions and the provision of financial services.”²³ This is the FSB’s definition of fintech as well.²⁴



BOX 3: DEFINITIONS (CONTINUED)

Sustainable finance

The G20 SFSG 2018 Synthesis Report (forthcoming) highlights that in order to benefit from an array of efforts to mobilizing private capital to support sustainable growth and a stable financial system, additional aspects of sustainable development should be considered alongside environmental ones. Hence, it proposes the adoption of the more encompassing term of sustainable finance. According to the 2018 Synthesis Report, sustainable finance can be broadly understood as financing as well as related institutional and market arrangements that contribute to the achievement of strong, sustainable, balanced and inclusive growth, through supporting directly and indirectly the framework of the SDGs. Sustainable finance looks after financial market stability and its overall efficiency. In 2018, the SFSG is focusing on pursuing positive environmental impacts of investments that could generate social and economic co-benefits (e.g. job creation, growth enhancement, technological development, poverty reduction and social inclusion).

The SDGs were adopted in September 2015 by the United Nations General Assembly's 194 countries as a set of common goals to end poverty, protect the planet and ensure prosperity for all. The 2030 Sustainable Development Agenda and SDGs emphasize the need to drive inclusive and sustainable economic development.

Sustainable finance also builds on G20's Green Finance Study Group in 2016 and 2017, where green finance was understood as the "financing of investments that provide environmental benefits in the broader context of environmentally sustainable development".²⁵ Opportunities in green finance cover all financial sectors and asset classes, including bank lending for renewable energy and energy efficiency, green equity investment, green bonds and environmental and climate risk insurance. Hence, sustainable finance could be understood as financing of investments that provide environmental benefit and that include consideration of the additional aspects of sustainable development.

Sustainable digital finance

While there is yet to be a common definition, the definitions above suggest that sustainable digital finance may be understood as an intended application of digital finance towards financing as well as supporting the related institutional and market arrangements that contribute to the achievement of sustainable development.

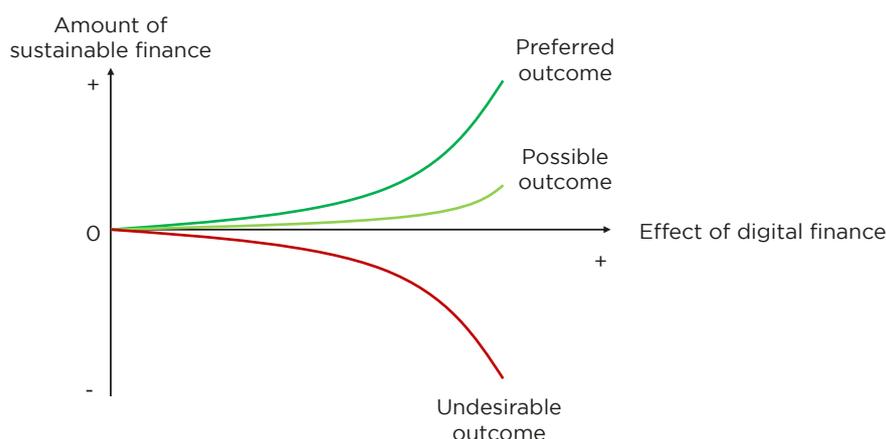
Figure 2 shows the uncertainty and possible outcomes that digital finance could have on levels of sustainable finance. The

unintended consequences of digital technologies, if not appropriately managed may lead to negative or small positive impacts on levels

of sustainable finance. Achieving the preferred outcome, where digital technologies increase levels of sustainable finance, will likely require policymakers and international cooperation to address potential market failures, cross-border issues and common risks.

While new technologies continue to unfold, the key technologies underpinning digital finance with the greatest potential economic impact are big data, artificial intelligence, cloud computing, online and mobile platforms, blockchain, and the IoT (see Box 4 for more details).

FIGURE 2: RELEVANCE OF DIGITAL FINANCE TO THE SUSTAINABLE FINANCE AGENDA



BOX 4: DEFINITIONS OF DIGITAL TECHNOLOGIES AND APPLICATIONS UNDERLYING DIGITAL FINANCE

Data and Automation:

- **Big data** aggregates large amounts of increasingly complex data from many different internal and external sources, unlocking opportunities for real time business insights.²⁶
- **Machine learning and artificial intelligence** ('MLAI') use advanced computer science and algorithms to analyse vast datasets, derive patterns to predict behaviour and prices, automate decisions or provide recommendations, dramatically increasing decision-making capabilities.
- **Cloud computing**, which is computing based on the Internet, enables IT services to be accessed anytime from anywhere and delivered as a service. It makes leveraging massive amounts of data and providing flexible, scalable processing platforms cost-efficient, fast and robust.
- **Robotic Process Automation** uses software to automate repetitive processes, notably back-office administrative processes.
- **Open banking APIs** may meaningfully change to the way that customers access financial services by requiring banks to give third parties access to their client data through application programming interfaces (APIs), which will drive competition and innovation in retail banking by providing consumers with more visibility, analysis and control over their finances.



BOX 4: DEFINITIONS OF DIGITAL TECHNOLOGIES AND APPLICATIONS UNDERLYING DIGITAL FINANCE (CONTINUED)

Highlight from Canada: Plans to invest US\$950 million in supercluster innovation centres to develop AI solutions applied to supply management systems, which will have a groundbreaking impact on sustainable and inclusive economic growth.²⁷

Mobile technology and new financial applications:

- **Mobile technology:** has evolved rapidly from a simple two-way pager to a mobile phone, GPS navigation device and web browser. Advancements in mobile technology have unlocked ‘mobile money’ and enabled computer programmes to run on mobile through applications that create access to a vast range of goods and services (see below).
- **Mobile money:** allows consumers to store national currency and make payments without having a traditional bank account. National currency is stored as credit on smart cards or a system provider’s books, and enables online or mobile phone payments. A well-known example is M-Pesa in Kenya, which reached a penetration of 80% of households in four years.²⁸ These systems can offer lower fees and easier use than traditional payment systems, even for those without a bank account
- **Person-to-person (P2P) platforms:** electronic money transfers made from one person to another through an intermediary, sent and received via mobile device or any home computer with access to the Internet, offer a convenient alternative to traditional payment methods. P2P originated with Paypal, which in 2014 handled a volume of transactions of US\$228 million. There are many innovators in the P2P transaction mobile space, with industry leaders such as PayPal, Venmo, Square, Inc., among myriad others. All of these apps allow users to easily and quickly send and receive payments, with little to no fees involved.
- **Investment crowdfunding platforms:** raise small amounts of money from a large number of people to fund a venture or project, including both equity and debt stakes, thereby opening up new investment opportunities for lenders and sources of capital for borrowers.

Highlight from India: The digital payments sector in India is estimated to grow to US\$500 billion by 2020, up from roughly US\$50 billion last year.²⁹

Blockchain technology:

- **Distributed ledger technology (‘DLT’) or blockchain** is a shared database of trusted transactions distributed across large peer-to-peer networks. The encrypted, distributed nature of data on the blockchain and system of consensus makes it inherently secure, immutable, verifiable and transparent to store transactions and

BOX 4: DEFINITIONS OF DIGITAL TECHNOLOGIES AND APPLICATIONS UNDERLYING DIGITAL FINANCE (CONTINUED)

records. Blockchain technology can ‘tokenize’ natural capital and incentivize behaviours. It also enables programming pre-agreed conditions that are automatically executed once certain procedures and if certain conditions are met. These ‘**smart contracts**’ (for example selling assets at a certain price) can be executed without the need for a third party that controls the release of assets.

Highlight from Australia: *The Australian Securities Exchange (ASX) announced in December 2017 the adoption of blockchain technology to record shareholdings and to manage the clearing and settlement of equity transactions.*³⁰

Internet of Things:

- **Internet of Things (IoT)** through low-cost connected sensors and AI is resulting in machine learning that automates discoveries and enables ‘intelligent’ computers capable of non-routine tasks. IoT will change the way businesses and consumers interact. By 2025, it is estimated that the IoT’s economic impact will be around US\$1.1 trillion – about 1% of today’s global GDP.³¹

Highlight from China: *In 2009, China’s State Council approved to build a national-level innovative demonstration area of sensor networks in Wuxi, signalling the start of China’s IoT and the “Sensing China” vision. This larger vision encompasses innovations in health, manufacturing, transportation, and environmental sustainability. The business revenues from core IoT industries jumped to over RMB200 billion in 2016 (approximately US\$30 billion), creating more than 150,000 jobs.*³²

Highlight from Saudi Arabia: *In 2017 Saudi Arabia’s government revealed plans to build a city on the ideals of technology and ecological innovation. The investment would be around US\$500 billion and “everything will have a link with artificial intelligence (AI), with the Internet of Things (IoT)”.*³³

These technologies impact the financial and real economy at different levels and bring about different benefits to sustainable outcomes. At the bottom of the pyramid in Figure 1, digital finance enables greater investment in sustainable assets and projects. Its ability to automate and make the availability, processing and analysis of large amounts of data cheaper, faster and more accurate overcomes information

asymmetries, better identifies and prices risk, and enables public institutions to more effectively track the regulatory aspects of sustainable development. Moving up the pyramid, digital finance unlocks greater inclusion and innovation, creating more opportunities to align finance with national sustainable development priorities. At the top of the pyramid, the interaction between innovations in digital

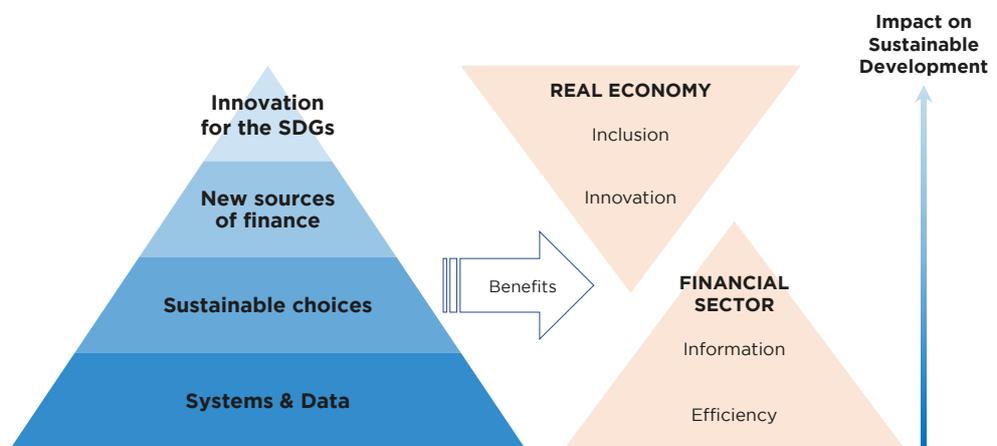


finance and innovations in the real economy facilitate new investment configurations and business models, reducing sustainable business models' risks, and creating opportunities to scale sustainable investments, particularly by PE/VC. At the same time, interactions between sustainable development and the efficient use of capital at the top of the pyramid may

be more complex and create unintended trade-offs.

In line with G20 SFSG 2018 Synthesis Report's focus on capital markets and PE/VC, this paper will focus predominately on the first layer of the pyramid, while also highlighting most current developments with respect to the other layers.

FIGURE 3: HARNESSING DIGITAL FINANCE TO ENHANCE THE MOBILIZATION OF SUSTAINABLE FINANCE







02

HOW CAN DIGITAL FINANCE ENHANCE THE MOBILIZATION OF SUSTAINABLE FINANCE? APPLICATIONS OF DIGITAL TECHNOLOGIES TO SUSTAINABLE FINANCE

Based on a mapping of sustainable digital finance practice across G20 members and the private sector, this section highlights how digital finance is overcoming the challenges to the mobilization of sustainable finance, particularly as these relate to capital markets, private equity and venture capital. It also highlights the extent to which different technologies are being used to achieve sustainable outcomes.

Findings demonstrate that the level of integration of digital technologies that are being used to mobilize sustainable private capital varies along a continuum. Mobile technologies and big data are relatively prevalent, whereas applications involving blockchain and IoT are still quite nascent. Big data, MLAI and to a lesser extent blockchain are increasing

efficiencies on the back end of financial institutions; reducing information asymmetries and costs associated with designing financing instruments for long-term green assets; increasing transparency; and improving the capacity of investors to identify, assess and price risk. Findings also highlight that new technologies such as IoT, combined with mobile technology, are unlocking new business models, making the deployment of sustainable capital particularly by private equity and venture capital more attractive.

Table 1 provides examples from the mapping to highlight these findings, and Table 2 summarizes the extent to which different digital technologies are being used to achieve sustainable outcomes based on the mapping.

TABLE 1: EXAMPLES FROM MAPPING OF SUSTAINABLE DIGITAL FINANCE PRACTICES ACROSS G20 MEMBERS AND THE PRIVATE SECTOR

	Investment	Incentivizing sustainable choices	Unlocking new sources of finance	Interaction between innovations in the financial sector and real economy
Big data	<p>NG Real Estate Finance (EU) digitizes commercial real estate assets and analyses energy efficiency modifications, which enables lower costs of capital for sustainability loans.</p> <p>Sustainalytics (UK) provide predictive analytics for smart climate investing and cheaper incorporation of environmental, social and economic considerations into investment decision-making.³⁴</p> <p>TruValue Labs (US) is a customizable AI-powered engine that helps investors identify sustainable investments they are interested in. It uses machine learning and natural language processing (NLP) to analyse unstructured data in real time, extracting relevant metrics and turning them into material insights for investment decision-making.³⁵</p>	<p>Ant Forest (China) creates incentives to green citizens' consumption patterns by using mobile payment platforms, big data and social media.</p> <p>Bundles (EU) has moved beyond the start-up phase to structure long-term financing. It sells washing cycles instead of machines, with devices monitoring use and statistics displayed in an app and incentivizes more water efficient washing practices.³⁶</p>	<p>Crowdear (Argentina) is a rewards-based crowdfunding platform. The main objective is to unlock new sources of finance and encourage entrepreneurs to focus on projects applying technology to education, health, and environment outcomes.³⁷</p> <p>Brazil Innovation Lab for Climate Finance crowds in innovative sustainable investment solutions, many of which leverage digital finance. For example, Community Solar, is an online marketplace of community solar and wind projects that connects energy consumers paying a monthly rent and investors receiving the fee.³⁸</p> <p>CleanTek Market's (Australia) platform connects clean technologies projects and organizations with finance and other market participant.³⁹</p> <p>EcoCrowd (Germany) is a crowdfunding platform specialized in green projects and sustainable initiatives.⁴⁰</p> <p>EcoFinance's (Russia) online service allows the under-banked to send loan applications via SMS or the web, with funds accessible in minutes.⁴¹</p> <p>YOLK (South Korea) used crowdfunding to raise finance for a solar charger.⁴²</p> <p>StartMe (South Africa) enables entrepreneurs, schools and communities to utilize a crowdfunding platform to raise funding for projects.</p>	<p>Canada plans to invest US\$950 million in supercluster innovation centres to develop AI solutions applied to supply management systems, which will have a ground-breaking impact on sustainable and inclusive economic growth.⁴³</p> <p>BioMachines (Indonesia) is helping with sustainable cocoa farming by using sensor technology to gather environmental data from experiments, and enable knowledge transfer to cocoa farmers. Such data driven practices can unlock access to finance for farmers.⁴⁴</p> <p>Simpa Networks (India) uses a rooftop leasing model made possible with mobile payments and control technology to unlock investments in solar home solutions for last mile markets.⁴⁵</p> <p>Telecom Italia (Italy) is building a new wireless network for IoT. Smart meters for homes and utilities are expected to be among the first devices to be connected in order to improve water and electricity consumption.⁴⁶</p> <p>Sustainable Smart Cities Project (Japan) helps to better balance demand and supply side across various sectors, making infrastructure investment more efficient by limiting large scale investment in the supply side.⁴⁷</p> <p>Mexico City is using a "Smart grid" system which includes traffic management and incident detection, operating 20,000 sensors and cameras around the city. It has helped reducing electricity theft. Disaster and environmental monitoring are also included to keep supplying data into making the city even smarter.⁴⁸</p> <p>Istanbul (Turkey) has deployed the "Smart Cities" to implement IoT technologies to improve transportation administration and the environment, which will transform infrastructure financing.⁴⁹</p>
MLAI				
Mobile platforms				
IoT	<p>The Shenzhen Green Finance Committee (China) is piloting the use of blockchain and IoT chips embedded in green assets to digitize the green certification and verification process.</p>			
Blockchain	<p>Nespresso (France) has launched a blockchain-based register to track climate-positive actions to share positive social and environmental impacts with shareholders.⁵⁰</p> <p>The Islamic Development Bank (Saudi Arabia) plans to use blockchain to develop sharia-compliant products, to meet demand from Muslim investors, with firms from Indonesia to Canada, and allowing instantaneous clearing and settlement of transactions and assets exchanges.⁵¹</p>			



TABLE 2: EXTENT TO WHICH DIGITAL TECHNOLOGIES ARE BEING USED TO ACHIEVE SUSTAINABLE OUTCOMES

	Systems & Data	Sustainable choices	New sources of finance	Innovation for the SDGs
Machine Learning/AI	High adoption	Early adoption	Prevalent	Early adoption
Big data	Prevalent	Early adoption	Prevalent	Early adoption
Mobile/financial applications	Prevalent	Prevalent	High adoption	High adoption
Blockchain	Nascent	Nascent	Nascent	Nascent
IoT	Nascent	-	Nascent	Nascent

02.1 Digital Finance and Systems and Data: Greater Efficiencies, Information and Transparency

02.1.1 Improving Back-end Efficiencies

While not unique to sustainable finance, digitization and the automation of back-end processes offer large-scale cost reductions, combined with increases in the flexibility and accuracy of back-office tasks. In recognition of the gains, financial institutions continue to invest heavily in digitization. For example, banks in North America spent US\$62.2 billion on external IT, and it is estimated that in 2017, US\$35 billion will be spent on core processing alone.⁵² At the same time, large financial institutions continue to run their core systems on legacy IT infrastructure that is expensive to maintain and that impedes institutions' ability to have a unified view of data across silos. Estimates indicate that 90% of technology budgets for financial institutions from North American and European financial institutions are spent on managing and maintaining legacy systems.⁵³

Within capital markets, digital finance has enabled greater automation on the buy-side, reducing cost frictions. The automation of processes in bond issuance allows borrowers to connect directly to more diversified sources of funding. While not yet widely adopted, such automation has the potential to further reduce the design and financing costs of green bonds and loans, and to bring environmental benefits such as widespread paperless operations.⁵⁴ However, there is also likely to be a reduction in jobs, particularly for repetitive tasks, which on the one hand raises concern of job losses, and on the other could free employees up to focus on higher-value tasks.

Similarly, it has been estimated that robotic automation of repetitive tasks, particularly in operations and finance, could reduce costs by 50 to 70% for high-frequency tasks.⁵⁵ It has an established track record of producing tangible, measurable results in the capital market and banking industry.⁵⁶ Blockchain could also further reduce the costs of back-office functions and security

clearing. Some have estimated that distributed ledger technology could save bank infrastructure costs around US\$15-20 billion a year and the world's largest investment banks could reduce their infrastructure costs between US\$8 to US\$12 billion a year.⁵⁷ For example, *Signatura* in **Argentina** is working on a blockchain-based product called 'Financial Passport' to share data, while assuring data transparency and integrity.⁵⁸ The project highlights how blockchain could be used to help financial institutions decrease paperwork and make processes faster. The **South African Financial Blockchain Consortium (SAFBC)**, comprising 22 industry leaders plus the South African Reserve Bank and the Financial Services Board as observers, is working to create a blockchain platform centred on reducing inefficiencies and promoting opportunities to reduce costs for institutions and end consumers.⁵⁹ Given the fast growing pace of these applications, human oversight of these machine learning underlying algorithms should be reinforced, and coding standards and best practices should be followed.

02.1.2 Increasing Access to Data, Reducing Information Asymmetries

Data is the backbone of investment decision-making as it helps investors better understand and quantify risk as well as risk-adjusted returns. Big data, machine learning and AI reduce the costs and time of gathering and analysing large amounts of complex data. These technologies are being widely applied in the financial sector to advance investment analytics; create low-cost robo-

investment advisors; determine creditworthiness from alternative data sources; automate credit approvals to seconds; and facilitate regulatory compliance. The development of smarter algorithms and faster machines that process unstructured information can make markets more liquid, accessible and efficient. In recognition of the potential of big data and MLAI, national governments and financial institutions are investing heavily in increasing these capabilities.

The prevalence of asymmetrical information is a key barrier to enhancing sustainable finance. In 2016, the GFSG highlighted that the lack of disclosure of environmental information could increase the 'search costs' for green assets, thus reducing their attractiveness. The lack of specific data that is easily available makes it expensive to measure and generate private data for tagging or labelling loans as sustainable. Hence, few banks are able to do so. This creates difficulties for institutional investors to understand the risks of unlabelled or vaguely labelled sustainable loans and to assess the true risks and nature of the investments. Similarly, PE/VC investors face difficulties in quantifying environmental benefits as well as in assessing and classifying investments' effects on society.⁶⁰ While publicly available environmental data (PAED) can improve access to environmental information related to investment decisions, there are challenges to effectively using PAED in financial analysis.⁶¹

Digital finance can reduce search costs for information about sustainable assets and loans, and address some of the key challenges



related to PAED. It is important for such data to be cleaned or scrubbed in order to detect and remove errors and inconsistencies to improve the data quality. Such technologies are being used by banks to offer lower costs of capital for real estate loans used for energy-efficient modifications, which could be bundled for institutional investors. For example, Case Study 1 (Box 5) illustrates how *ING Real Estate Finance* in the **Netherlands** digitizes commercial real estate assets and analyses the potential energy efficiency modifications using big data collected across hundreds of buildings and smart algorithms to prioritize capital utilization that will increase the value and performance of the building. By making data

on the energy efficiency gains of capital investment easily available, commercial real estate lenders can lower the cost of capital for loans that demonstrate that they fulfil certain sustainability criteria. Investment analysis, risk assessment and credit approvals of underlying sustainable loans can also be automated to bring about more efficiency gains. Case Study 2 (Box 6) highlights how blockchain technology can be used to provide environmental and social impact data to improve financial risk assessments and access to finance. The blockchain enables such data to be provided in a low-cost, transparent and verified manner, lowering the cost of capital, particularly in emerging economies.

BOX 5: CASE STUDY 1 - BIG DATA AND AI REDUCE SEARCH COSTS OF ENVIRONMENTAL PERFORMANCE INFORMATION, PROMOTING GREEN COMMERCIAL REAL ESTATE LOANS

Digital finance is being used to address information asymmetries and lower costs of capital for financing green commercial loans. In the **Netherlands**, *ING Real Estate Finance (REF)* worked with technology partner CFP Green Buildings in 2015 to help their borrowers identify the energy improvement measures for their buildings that provided the most attractive financial returns and greatest carbon emission reductions. As a result, a web-enabled application using big data was developed and offered to all Dutch clients. The borrower enters certain basic information about their buildings such as the type, age of construction and floor area. The app analyses their portfolio and recommends the top 10 measures per building to lower energy costs and reduce CO₂. Within its first two years, the app had been used to scan 18,000 buildings measuring 10 million m² (65% of ING REF's financed portfolio). Building on this early success, ING plans to scale this application to other European countries. As part of this project, ING started providing discounts on 'sustainable loans', as well as providing subsidy advice and offering free Energy Performance Certificate assessments for its clients.

In the first year and a half of the collaboration, CFP consultants identified more than EUR35 million (approximately US\$40.6 million) in annual energy cost savings, leading to higher asset values and a lower carbon footprint of the portfolio. In this case, the cost of lending reflects the sustainability of the building. Consequently, sustainable buildings should be more likely to be financed than unsustainable ones.

Machine learning and AI improve the integration of environmental, social and economic considerations into active investment decision-making by leveraging vast amounts of data to better identify, assess, and price sustainable investments.

For example, *TruValue Labs*⁶² in the **US** is a customizable AI-powered engine that helps investors identify sustainable investments that fall under their target. It uses machine learning and natural language processing (NLP) to analyse unstructured data in real time, extracting relevant metrics and turning them into material insights for investment decision-making. Also in the **US**, the *Natural Capital Project* offers Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST), a free and open-source software to inform and improve natural resource management and investment decisions. InVEST quantifies, maps, and values the goods and services from nature that contribute to sustaining human life.⁶³ The *Centre for Social and Sustainable Products (CSSP)* in **Switzerland** is the technology and innovation incubator behind yourSRI.com – a fintech platform that screens about EUR15 trillion (approximately US\$17 trillion) of assets under management per day, enabling investors with one click to create environmental, social and climate investment ratings, key performance indicators and investment reports for mutual funds, exchange-traded funds (ETFs) as well as discretionary investment mandates.⁶⁴ yourSRI.com brings together traditional financial data (Thomson Reuters/Lipper), ESG data (MSCI ESG Research) as well as carbon data (ISS-Ethix) to

automatically determine a fund's environmental and social score as well as its carbon footprint, creating transparency for sustainable investment decision-making. Similarly, in the **UK**, *Sustainalytics*⁶⁵ leverages big data and AI to provide cheaper incorporation of environmental, social and economic considerations into investment decision-making. Sustainalytics' data services enable investors to integrate environmental and social research into their internal or third-party systems (such as Bloomberg). Data delivery is automated and allows the creation of databases, reports and dashboards to facilitate analysis and decision-making.

Digital finance technologies are also enabling the development of sustainability rating methodologies, benchmarking and indexes promoting more sustainable passive investments.

FTSE Russell in the **UK** expanded its Sustainable Investment index offering to align sustainability considerations with passive investment objectives with the launch of the FTSE Global Climate Index Series and the FTSE ESG Index Series.⁶⁶ The new smart Global Climate Index uses data from the FTSE Green Revenues data model to hedge climate-related risks and gain exposure to the upside opportunities from the transition to a low-carbon economy. In **Germany**, *Deutsche Bank* in conjunction with *Solactive* announced the launch of the *Solactive Sustainability Index Europe*, with the purpose of tracking the performance of environmentally and socially responsible European firms. The index is based on the S-Ray platform, a data driven-machine



learning investment tool.⁶⁷ The *VanEck Vectors Green Bond ETF* is the first **US**-listed fixed income exchange-traded fund (ETF) for green bonds, which offers a way

to invest in a diversified portfolio of US and foreign green bonds. It tracks performance and yield characteristics of the S&P Green Bond Select Index.

BOX 6: CASE STUDY 2 - USING DLT TO PROVIDE ALL PARTIES WITH TRANSPARENT, VERIFIED IMPACT DATA FOR BETTER FINANCIAL RISK ASSESSMENT AND ACCESS TO FINANCE

Six international companies, banks and four fintech start-ups will be piloting an initiative developed by a new *Banking Environment Initiative Fintech Taskforce* in the **UK** convened by the University of Cambridge Institute for Sustainability Leadership. The aim is to test whether blockchain and other technologies can help unlock financial incentives that reward sustainability in supply chains.⁶⁸

Launched in December 2017 at the One Planet Summit in Paris, the aim of the project is to help banks and the companies they finance to access more detailed and reliable information about the social and environmental impact of their entire supply chains, and in turn reward sustainability with access to faster and cheaper working capital.

The technology will gather and record standardized information from farmers about their produce using virtual identifiers that are encoded on a blockchain, making information to all parties that can access that blockchain traceable and transparent. Financial institutions may then offer preferential terms or access to credit based on the evidence of sustainability supported by the blockchain. Through access to cheaper working capital, smallholders will be able to increase investments in their farms to become more productive without needing to convert more land.

Through the use of blockchain-enabled smart contracts, the system manages the trade workflow, measures sustainability and transparency data, and automates access to trade finance at preferential rates. The system brings together transparent data and verifiable sustainability claims, with conditional access to finance. With easy access to the supply chain data on the blockchain, banks will be able to better assess risk and make decisions around financing. If successful, the outcome of the pilot could ultimately benefit the 1.5 billion families who depend on small-scale agriculture worldwide.

Another example is in **India**, where the *Mahindra Group*, in collaboration with IBM, announced the development of a blockchain solution for the supply chain finance. The blockchain-based supply chain finance solution will allow all parties involved in the operation to act on the same shared ledger, with each party updating only their part of the process, guaranteeing efficiency, consistency, trust, transparency and security. The Group is looking at other applications in financial services, auto, mobility and agritech.⁶⁹

Digital finance can also address some of the key challenges related to PAED. The technology underlying big data can allow non-standardized data to be standardized, and presented in ways that make sense for financial users. While there may be several examples of in-house solutions to map out risk based on PAED, there seems to be a lack of standardized solutions available to investors. Fintech start-ups like *Global AI* in the **US** are aiming to bridge this gap by providing investor dashboards powered by AI, which draw on PAED and big data relevant to the SDGs.⁷⁰ Another example is *Palantir* in the **US**, which integrates massive volumes of different data sets to help governments and organizations prepare for and respond to natural disasters and economic crises. It integrates publicly available data, damage assessments, satellite imagery, weather reports, geospatial information on key infrastructure and relief resources, as well as reports from news agencies and governments – all available in a unified environment for users to search, analyse and explore.⁷¹

On the supply side of PAED, international agencies recognize the limitations of traditional data mechanisms and are working towards solutions. The United Nations Environment Programme, for example, has developed *UN Environment LIVE*,⁷² an online dashboard that draws from multiple data streams quickly and at low cost. One example is the mapping and geo-tagging flood risks globally with the use of the Global Assessment Report (GAR) Atlas global flood hazard assessment. This type of information can be of great value to investors. The demand of

new and innovative approaches to PAED by fintech-empowered investors can foster greater supply of real-time and more accurate environmental indicators.⁷³

02.1.3 Addressing Maturity Mismatch – Green Bonds and Loans

In 2016, the GFSG emphasized green bonds as an example of financial sector innovation that could address the problem of maturity mismatch. However, the GFSG also highlighted the challenges with respect to scaling the green bond market, including the costs of labelling and verifying green bonds, and of monitoring the use of proceeds by issuers for green purposes, as well as the lack of green bond ratings, indices and listings.

Digital finance technologies can reduce data costs associated with ‘labelling’ and verification of green assets, a systematic process where banks identify and verify the environmental attributes of their loans and underlying asset collateral using a transparent definition of green as a tool for scaling up sustainable finance.⁷⁴ Blockchain technology allows the ‘greenness’ of investments to be verified and audited in a secure, transparent and immutable manner, increasing confidence and lowering costs associated with green labelling. For example, when monitoring the use of proceeds, technology can be utilized to screen the documentation to ascertain that the proceeds are actually used to finance sustainable projects. Especially in less transparent markets, using blockchain technology that collects cross-referenced data to verify sustainability claims is a very useful tool. Embedding IoT in green assets



allows it to act as a technology intermediary by automatically and cost-effectively tracking and tracing the performance of the asset. While this reflects an area of high potential, many of these technology

solutions are nascent, mostly in pilot stages. A number of ongoing pilots use digital innovation to validate green investments through blockchain (Box 7).

BOX 7: CASE STUDY 3 - LOWERING THE COSTS OF VALIDATING GREEN INVESTMENTS THROUGH BLOCKCHAIN AND THE INTERNET OF THINGS

In **China** in 2017, the Energy Blockchain Labs, International Institute of Green Finance, the China Emissions Exchange and the Shenzhen Stock Exchange, coordinated by the *Shenzhen Green Finance Committee*, established a joint project to digitize and automate the process of green finance certification using IoT and blockchain. The project aims to leverage the power of digital finance to solve problems in the green finance certification system, including insufficient information disclosure, and limited efficiency in the certification process.

IoT chips embedded in the green assets such as panels in solar power plants will gather information for green finance certification. AI algorithms and smart contracts will process data and evaluation results will be transmitted and recorded on the blockchain to ensure the evaluation process is transparent, standard compliant, and tamper-resistant. Certification results are stored on blockchain in a distributed way, which allows access to all relevant parties, including project managers, financial intermediaries and regulators.

This digital green certification process brings a number of benefits. Green certificates will enable the owners of the green assets to access financial resources at lower costs. The distributed nature of blockchain technology will enable the system to capture and record small-scale green assets like roof-mounted PV power systems, which benefit disadvantaged and broader segments of society. Financial intermediaries will have access to authentic data without high auditing expenses, and regulators can conduct real-time risk assessments as they have access to granular information on the daily operation of the assets underlying a given financial product.⁷⁵

Also in **China**, *Beijing Nenglian Zhonghe Technology Co., Ltd.* combines IoT and blockchain to create a green asset information service platform for financial markets. Data from green assets is collected through IoT, stored in real time on the blockchain, and converted into financial information. The characteristics of the blockchain meet the financial markets requirements for asset information that is trusted and traceable, thereby unlocking investment.

In **Sweden**, a “*Green Asset Wallet*” innovation project aims to increase sustainable investment through a blockchain platform that reduces information asymmetries and increases efficiency and transparency in

BOX 7: CASE STUDY 3 - LOWERING THE COSTS OF VALIDATING GREEN INVESTMENTS THROUGH BLOCKCHAIN AND THE INTERNET OF THINGS (CONTINUED)

the green debt market.⁷⁶ It brings together a diverse set of partners – commissioned by the German Ministry for Economic Cooperation and Development (BMZ), funded and co-developed by GIZ's Emerging Markets Dialogue on Finance, incubated by Stockholm Green Digital Finance, and built by a consortium of financial institutions, research institutes and fintech partners from Nordic and emerging market economies. The platform, which will enable cost-effective and immutable verification of green impact, is built around three elements:

- Validating delivery and green claims of green investments: through the verification of evidence points (e.g. engineering reports, certification schemes and labels, satellite footage) and validation by accredited validators (e.g. engineering or auditor firms, certification organizations, IoT devices). A smart contract is then activated that confirms delivery on green claims.
- Impact reporting: The Green Assets Wallet puts impact reporting on the blockchain to support issuers and investors to demonstrate positive impact. Projects can report back on m³ of cleaned water, kWh of solar electricity generated, etc. The technology enables aggregation, selection of specific sector reports and avoids double spending.
- Credibility of new entrants: The Green Asset Wallet helps new entrants demonstrate credibility and a track record to successfully engage with investors and tap into the green debt market. Building upon the green deliverables recorded in the blockchain, the Green Assets Wallet can feed this back to investors. This is particularly valuable for easing access to PE/VC capital and help new entrants grow and create job opportunities.

Nespresso (France) has launched a blockchain-based register to track climate-positive actions. The coffee brand had its Agroforestry Insetting Program certified last year by Ecocert, and listed on the blockchain registry of the International Platform for Insetting (IPI), which supports companies to share positive social and environmental impacts with shareholders.⁷⁷

02.2 Incentivizing More Sustainable Choices

Digital finance is also demonstrating its potential to incentivize citizens to make more sustainable and resource-efficient consumption choices. Digitalization of purchasing decisions can influence consumers' behaviour by reducing search costs in selecting products and

services that align to their personal values. Digital technologies provide information and transparency about the environmental and social impact of consumption choices. Such opportunities are facilitated by the growing deployment of IoT that provides low-cost data on sustainability impacts. Big data and AI can translate financial transaction data into carbon



footprints, highlighting to citizens for the first time the environmental impact of their purchases in real time. Combined with social media, this creates opportunities for large-scale awareness and mobilization campaigns that enable consumers to make finance-related choices more aligned to sustainable development outcomes. Greater demand for environmentally friendly products and services will increase investment in greener production.

For example, *Ant Financial Services*, in association with UN Environment, has initiated 'Ant Forest' in **China**,⁷⁸ the world's first large-scale pilot to green citizens' consumption patterns by using mobile payment platforms, big data and social media. The 'Ant Forest' encourages Ant's users to reduce their carbon footprint through a three-part approach: (a) providing individualized carbon savings data to people's smartphone, (b) connecting their virtual identity and status to their earnings of 'green energy' for reduced carbon emissions, and (c) providing carbon offset rewards through a physical tree planting programme. Over the first sixteen months from August 2016 to December 2017, 280 million people across China voluntarily joined this app, which resulted in over 2 million tons of cumulative carbon avoided and over 13 million trees planted. Success drivers are being analysed to ensure continued widespread use. Work is also being undertaken to explore the possibilities of extending and localizing this experience to other country contexts.

Another example is *Bundles*⁷⁹ in the **Netherlands**, a start-up that sells washing cycles instead of washing machines. Through a leasing

model, it offers appliances that use relatively little energy, water and detergent and last twice as long as the average appliances. A device monitors how the washing machine is used. Statistics are displayed in an app, providing customers with insights into the overall cost of doing the washing, including energy and water. To stimulate 'good behaviour', customers who use the machine optimally are rewarded with reduced monthly fees. In collaboration with Rabobank, Bauwinvest and Miele, Bundles has been taken beyond the start-up phase to explore ways to structure long-term funding that structures relationships within the supply chain using a circular economy approach. It is funded through crowdfunding and equity support.

Digital finance also empowers citizens to better align non-financial and sustainable development objectives in their role as retail investors, and as pension and insurance policyholders. While roughly 70% of individuals in Europe want their investment portfolios to reflect these objectives, according to the 2 Degrees Investing Initiative, to date, these non-financial objectives are poorly profiled in retail and pension markets, and not necessarily integrated into portfolio mandates.⁸⁰ Digital technologies enable citizens to translate non-financial objectives into investment strategies. As a result, as pension and insurance policyholders, they can demand and be offered more choices for the deployment of their long-term savings, and become more active along the financing value chain (see Box 8).

BOX 8: DIGITAL FINANCE ENABLING CITIZENS TO TRANSLATE NON-FINANCIAL OBJECTIVES INTO RETAIL INVESTMENT STRATEGIES⁸¹

In order to help citizens reflect non-financial objectives into the financing value chain, the 2 Degree Investing Initiative (2°ii) is building a quantitative client profiling software on non-financial objectives and an associated platform that can be used by banks and consumers to translate their non-financial objectives into investment beliefs and strategies.

This involves:

- An open-source client profiling questionnaire for non-financial objectives that allows for a matching of non-financial objectives with funds. The questionnaire will be integrated into a software that allows users to print their individual client profile as a one-page factsheet. All outputs will be IP-rights free allowing for integration by banks and other stakeholders into their systems.
- A fund-matching software that allows for the matching of funds in terms of their compatibility with different client profiles. The software is designed to work seamlessly with the questionnaire. Both the matching software and the questionnaire will be available to retail investors and banks alike on a non-commercial informational website.
- The analysis will build on the 2°C scenario tool developed by the 2°ii and applied by over 200 financial institutions to date. The tool allows for a granular assessment of the portfolio to a range of high-carbon and low-carbon technologies and assets, as well as its alignment with a 2°C scenario. The assessment can also integrate other sustainability criteria and data such as board diversity, armaments and tobacco. The software source code, methodology and any related documentation will be made publicly available.
- An engagement/white label tool. The outputs can be used by market actors across a range of use cases:
 - A software for pension funds to profile the non-financial objectives of their beneficiaries and directly link the results with investment mandates and underlying strategies. Results could allow pension funds to develop blended strategies consistent with the preferences of their beneficiaries or motivate divestment decisions. This application can be implemented jointly with a bank to directly connect the dots to the investment strategy.
 - A software for banks to use in their retail banking business to allow frontline advisors to identify the non-financial objectives of their clients and match these to their fund offering. The software can be applied directly to or together with the client.
 - An online robo-advisor for retail investors to apply independently and inform investment decisions or their dialogue with their banks or robo-advisors.



Similarly, investors can more easily choose to invest in areas with impacts more closely aligned with personal values. For example, *Impacton* in the **UK** uses MLAI to assess and scale proven sustainable solutions across countries. Leveraging digital technologies, *Impacton* makes such solutions available to citizens and groups interested in financing replications in new locations. This creates a low-cost licence model to scale proven sustainable businesses.⁸²

02.3 New Sources of Sustainable Finance

Digital finance within the financial inclusion agenda is understood in terms of the role the technology plays in increasing access to, and use of financial services. Financial inclusion is a keystone to broader sustainable digital finance. It enables a larger variety of actors, including those of lower income status, to play a more direct role in the financial system, unlocking new sources of sustainable finance and expanding access to sustainable finance products and services.

Crowdfunding and P2P platforms provide low-cost ways of reaching millions of users. Such platforms enable a new pool of 'bottom-up' investors to directly participate in the financial system, facilitating access to finance particularly to small and medium-sized enterprises (SMEs). This is particularly important given that SMEs account for about 90% of business and more than 50% of employment worldwide, and are key engines of job creation and economic growth in developing countries.⁸³ Such platforms, when consumer protection and financial stability

issues are carefully addressed, could complement or enhance the capital offer by the PE/VC market, facilitating SMEs' access to a new pool of 'bottom-up' investors and finance. However, they are still limited in scale and volume. Crowdfunding – which raised US\$16.2 billion in 2014, a 167% increase from 2013 – was used for launching businesses (41%) compared with less than 20% for social causes.⁸⁴

Big data, MLAI and automation have also enabled new providers (such as Ant Financial in China) and alternative lending platforms, leveraging P2P and crowdsourcing models, to offer more convenient services that transform credit evaluation, allowing them to offer loans to a broader base of customers and a new class of investment opportunities to savers. For example, *Mercado Crédito* in **Argentina** analyses more than 400 variables in order to provide loans to small enterprises in order to unlock innovation for social impact.⁸⁵

Bearing in mind these opportunities to drive new sources of finance, it is crucial to work on expanding access to sustainable finance products. Under Argentina's Presidency, the GPMI focused on how digitization could be a tool to financially include those individuals and small businesses operating in the informal economy. This work resulted in the *G20 Policy Guide. Digitisation and informality: Harnessing digital financial inclusion for individuals and MSMEs in the informal economy*,⁸⁶ which illuminates for example on the role of alternative data to improve the access to credit by SMEs.

BOX 9: OTHER EXAMPLES OF PRACTICES FROM G20 MEMBERS AND THE PRIVATE SECTOR

Argentina: *Crowdear*⁸⁷ is a rewards-based crowdfunding platform. The main objective is to unlock new sources of finance and encourage entrepreneurs to focus on projects applying technology to education, health, and environment outcomes.

Australia: *Macquarie* has acquired Green Investment Bank and offers flat-fee digital investment advice services. *Acorns*, a micro-investing robo-advisors app, developed a socially responsible ‘Emerald Portfolio’ that allows users to invest more sustainably.⁸⁸ The *Green Crowd* offers traditional crowdfunding services at a fee, but specifically focuses on arts, community and technology within the green niche.⁸⁹ *RatteSetter*⁹⁰ is a P2P green lending platform for businesses and individuals.

Brazil: *Kickante* is a leading collective platform that focuses on financing projects with social impact. It has hosted over 8,000 campaigns with artists, charities and entrepreneurs, including an ecological sanctuary association in São Paulo. *Catarse* is another crowdfunding platform focused on raising collective finance for ventures that have social and environmental impacts, including low-carbon development, solid waste and infrastructure.⁹¹

Germany: *EcoCrowd*⁹² is a crowdfunding platform specialized in green projects and sustainable initiatives. The goal is to use the platform to provide both financing and support to further develop the project.

Italy: *Ecomill*⁹³ is an equity crowdfunding platform where households and firms can finance projects and new ventures in energy efficiency, sustainable mobility, renewables, smart grids, local economic development and environmental services. Additionally, the platform supports projects using its professional network to provide analysis for the development of the venture, and during the launch of their funding campaign.

Japan: *NPO Bank* has been an advocate of crowdfunding activities and such has been used to fund social investment and impact investment. For example investing in a local business engaged in the revival of forests in the village of Nishiawakura, Okayama Prefecture domestic crowdfunding market has expanded to ¥20 billion.⁹⁴

Republic of Korea: Start-up *YOLK*⁹⁵ used crowdfunding to raise over US\$1 million for a solar charger it developed.

Russian Federation: *EcoFinance*⁹⁶ has become one of the leading lenders for subprime and underbanked clients in Russia. It sets a solid emphasis on responsible lending. Their online service lets borrowers to send loan applications via SMS or website, and funds can be accessed in minutes. EcoFinance has over 1.6 million registered client accounts.



BOX 9: OTHER EXAMPLES OF PRACTICES FROM G20 MEMBERS AND THE PRIVATE SECTOR (CONTINUED)

Saudi Arabia: The research arm of the *Islamic Development Bank* plans to use blockchain technology to develop sharia-compliant products, aiming to promote financial inclusion across its member countries. Its aim is to leverage blockchain technology to meet demand from Muslim investors, with firms from Indonesia to Canada. Such features, besides assisting eliminating counterparty risks, would allow instantaneous clearing and settlement of transactions and assets exchanges.⁹⁷

South Africa: *Thundafund* is an online channel through which entrepreneurs can access capital and establish an initial market for their products and services. Thundafund combines financing with business mentorship to support businesses succeed. *StartMe* has been designed for entrepreneurs, schools and communities to utilize a crowdfunding platform to raise funding for projects. Via PayFast, anyone in South Africa can raise funding for a project. These crowdfunding business models vary in terms of repayment. Some models utilize rewards (products or services) as compensation, while others use interest or equity structures to compensate investors.⁹⁸

UK: *Abundance*⁹⁹ is an investment platform that allows anyone to invest in green energy projects. It also offers an online marketplace where investments can be traded in funded projects at any stage of the investment term.

US: *GreenFunder*¹⁰⁰ is a global crowdfunding site for green and socially responsible projects. Investors are rewarded with perks. GreenFunder charges a 5% fee for fully funded projects and 9% for partially funded projects. On top of this, a 3-5% processing and administration fee applies.

EU (Netherlands): *Oneplanetcrowd*¹⁰¹ is a crowdfunding platform focusing on sustainable projects. The crowd finances the loan, which can then be converted to shares for institutional investors. It is currently the Europe's leading sustainable crowdfunding platform with more than 25,000 investors and raised over EUR20 million since its launch in 2012. It has provided seed money and growth capital for more than 175 projects.

Online investment platforms are also creating marketplaces bringing together and 'matchmaking' sustainable technology businesses with finance and other market

participants. Such platforms offer a combination of curated deal flow, data on deals, and AI to match investors to their preference (see Box 10).

BOX 10: ONLINE PLATFORM COMBINED WITH AI UNLOCK ADDITIONAL SOURCES OF FINANCE THROUGH 'MATCHMAKING' INVESTORS AND INVESTEES

Australia: *CleanTek Market* is an online ecosystem enabling any organization active in the cleantech sector to connect with others and access finance through its platform. Its algorithms match organizations with each other. It uses a tiered validation process that aims to rate the “quality” of deal flow on its platform and its investment tools aggregate small projects into larger deals, enabling institutional investors to efficiently deploy increased flows into cleantech project portfolios.¹⁰²

Brazil: *Brazil Innovation Lab for Climate Finance* crowds in innovative sustainable investment solutions, many of which leverage digital finance. For example, Community Solar is an online marketplace of community solar and wind projects that connects energy consumers paying a monthly rent and investors receiving the fee.¹⁰³

Canada: *Convergence Finance*¹⁰⁴ has developed an online platform that generates blended finance data, intelligence and deal flow to increase private sector investment in global development in emerging markets by allowing investors to quickly search databases for credible deals. The platform broadens investors’ networks, simplifies their screening process, and also helps mobilize private sector investment for emerging markets through a market accelerator ‘Design Funding’ programme. The programme awards grants to support new financing vehicles to the investment stage in order to create sustainable investment assets and attract private capital at scale. As of May 2018, Convergence has awarded US\$5 million of grants to 15 projects targeting to raise US\$2 billion of investment, with US\$110 million raised (22 times leverage to date with 200+ times expected). Projects include a global network of affordable eye care hospitals (Alina Vision), one of the world’s first green banks in an emerging market (Coalition for Green Capital and DBSA) and a blue bond for conservation activities in small island states (the Nature Conservancy).

Switzerland: *Greenmatch*¹⁰⁵ is a Swiss company that digitalizes the investment process for renewable energy. It offers tools to value and assess renewable energy projects, calculate scenarios and manage proposals on a software as a service (SaaS) basis. This makes it easier for investors from public utility companies to banks, institutional investors, private equity funds, asset managers and citizens’ energy cooperatives to accelerate the evaluation of project pipeline. It also offers a marketplace, offering projects created in Greenmatch directly to potential buyers. The *Groundup Project* is another Swiss-based financial technology company that offers a deal sourcing platform for impact ventures leveraging AI. It standardizes and validates information about impact ventures, provides insights into business risk and reward, visualizes trends and aggregated data.¹⁰⁶



02.4 Digital Finance and Innovations in the Financial and Real Economy

02.4.1 Unlocking Innovative Sustainable Business Models

PE/VC funds are particularly well suited to identifying and scaling the best innovative business models and cleantech projects in both emerging and developed markets. To a large extent, these are both being unlocked by digital finance. One of the most well-known examples is how mobile payment platforms and digitally enabled solar assets have unlocked new sustainable business models, making the deployment of capital into off-grid companies serving excluded communities commercially viable. The ‘product as a service’ business model allows customers to use products through a lease or pay-for-use arrangement versus the conventional buy-to-own approach.¹⁰⁷ This enables payments to be adjusted to the cash profile of low-income groups, while smart technology (including low cost chips, circuits and IoT) within cleantech products makes it easy to remotely regulate the use and functionality of solar devices. Examples include *Simpa Networks* in **India**, *M-Kopa Solar* in **Kenya** and *Quetsol* in **Guatemala**.¹⁰⁸ M-Kopa’s proprietary platform combines GSM technology with a solar power kit to allow instalment and ‘pay-as-you-use’ financing for low-income customers in Kenya. In 2014, the Commercial Bank of Africa fronted a US\$10 million commercial-grade syndicated debt facility as part of a US\$20 million funding round. This investment marked the first time that a commercial loan was secured through mobile money provider M-Pesa receivables and was unique in that the loan book consisted

of low-income borrowers, many without bank accounts. Lenders included the Bill and Melinda Gates Foundation, LGT Venture Philanthropy, Imprint Capital and the Netri Foundation. M-KOPA has raised US\$45 million in total equity funding and debt financing. As at January 2018, it has connected 600,000 homes to affordable solar power as of January 2018 with a projected US\$450 million projected savings of current customers of over the next four years.¹⁰⁹ This model creates opportunities for company receivables to be securitized for institutional investors.

PE/VCS are also investing in business innovations brought about by the application of digital technologies to financial services, which could have negative implications for the future of the banking sector’s capacity to finance sustainable investments. Alternative lending platforms and non-bank technology companies are exploiting the mismatch in the banking business model, where McKinsey estimates that banks make 59% of their earnings from pure fee products, compared with balance sheet provision and fulfilment components of products. Similarly, opening banking, which requires banks to share client data with third parties, is increasing competition in retail banking. The **EU** has adopted opening banking through its Payment Services Directive (PSD2). This reduces dependencies on banks, which may leave banks with the basics of asset and liability management, reducing their capacity to make green loans.^{110,111}

Incubators and accelerators that focus on sustainable technologies are important in order to promote collaboration between start-ups

and reduce costly mistakes. While the number of energy accelerators in the **US** has increased from 5 to 19 since 2010, this is much lower compared with 178 accelerator programmes in 3,269 start-ups (over US\$10 billion in 2016) in the **US** and **Canada**.¹¹² Similarly, while most countries do not have incubators and accelerators that focus specifically on sustainable technologies, G20 members do have associations, chambers or conferences around digital technologies and fintech.¹¹³ There may be opportunities to influence accelerators and fintechs towards a greater focus on sustainable investments. Larger financial institutions are also investing heavily in innovation and new technologies, and new partnerships models are emerging. Banks in the **EU** and **Asia** are creating or financially supporting fintech accelerators or incubators (for example Level 39, Europe's largest fintech accelerator).¹¹⁴ The Monetary Authority of **Singapore** (MAS) also has its own fintech innovation lab called Looking Glass @ MAS as part of its efforts to encourage fintech co-operation and innovation.

Digital finance has also contributed to unlock sustainable business models arising from the interactions between the circular and shared economy, which could be well

suited for PE/VC allocations. Data, real-time transactions and the inherent scalability of digitally enabled business models help mitigate some risks for PE/VC investment. For example, the sharing platform model (such as Airbnb for lodging, Lyft for transportation, BlaBlaCar for carpooling) enables companies to maximize value creation. The resource recovery business model leverages technological innovations to reuse resource outputs, which eliminates leakages and maximize economic value (for example, closed-loop recycling), while the product life extension model helps companies extend the life cycle of their products and assets, reducing waste and creating new sources of revenue.¹¹⁵

IoT, big data and MLAI are disrupting business models in the insurance sector. These technologies have created 'usage-based insurance', which allows pricing to be based on actual behaviour rather than on traditional factors like location. This may however, undermine the insurance model of risk pooling, leaving some groups without access to insurance. Environmental IoT sensors with two-way communication also provide predictive alerts on potentially dangerous conditions, improving insurers' loss ratios.¹¹⁶

BOX 11: OTHER EXAMPLES OF PRACTICES FROM G20 MEMBERS AND THE PRIVATE SECTOR

Canada: *Opus One Solutions* offers a dynamic software platform that gives utilities, owners of distributed energy resources and other market participants visibility into the electricity distribution grid in real-time. This unlocks new customer and utility business models, and helps utilities determine where investments add the most value with the transition towards distributed grids.¹¹⁷



BOX 11: OTHER EXAMPLES OF PRACTICES FROM G20 MEMBERS AND THE PRIVATE SECTOR (CONTINUED)

France: A partnership between *Crédit Agricole Assurance* and *Airbus* is opening up new opportunities for grassland insurance. Grasslands are sensitive to climate variation and at the heart of livestock farming. Satellite imagery allows precise calculation of losses, which allows the development of innovative insurance products for farmers for the first time in this area.¹¹⁸

India: *Sarvaja*¹¹⁹ is a mission-driven social business that serves over 300,000 people with franchised water ATMs: automated water dispensing units where people can pay per use. Customers purchase prepaid cards and then top them up by paying agents in cash or via mobile payments. With over 180 water ATMs in 12 Indian states, *Sarvaja* is using digital finance tools to sustainably serve poor communities with safe, convenient water. *NeoGrowth* provides innovative unsecured credit products to MSMEs across India. It has established a unique business model that leverages point of sale terminals and transactions for credit underwriting and automated daily collection.¹²⁰

02.4.2 IoT and Sustainable Development

IoT deployments can have positive effects on a wide range of sustainability goals. IHS Markit estimates that the average annual number of connected IoT devices worldwide will reach 125 billion by 2030.¹²¹ According to the WEF (2018), an analysis of more than 640 IoT deployments showed that 84% of existing IoT deployments can address the SDGs. 75% of these concentrate on five SDGs, namely SDG 9 (Industry, innovation and infrastructure); SDG 11 (Smart cities and communities); SDG 7 (Affordable and clean energy); SDG 3 (Good health and well-being) and SDG 12 (Responsible production and consumption). The impact of IoT is so significant because at its core, IoT is about measuring and remotely controlling previously unconnected ‘things’, reaching people and objects that other technologies could not. Examples include a remote water-

monitoring solution that ensures clean water in regions with an indigenous population, and smart lighting initiatives in Chinese cities that halve total power output.¹²²

IoT projects whose main priority is to address sustainable development challenges are crucial, but an even greater impact could be achieved by prioritizing sustainability goals within commercially driven projects. While 84% of IoT deployments – 70% of which were driven by the private sector – are addressing the SDGs, companies do not necessarily see a direct link between their projects and the SDGs. This suggests that these projects’ significant impact on sustainability is almost unintended, or at least not their main driver.¹²³

One example of IoT for sustainable development comes from the Smart Green Infrastructure Monitoring project developed by

City Digital in Chicago, **US**. Their solution combines sensors and cloud-based analytics to evaluate the performance of sustainable storm water management techniques. Data from four green infrastructure sites helps reduce urban flooding and prevents property damage by enabling better informed capital planning for infrastructure investments. This has supported a US\$50

million allocation for green storm water management by the City of Chicago to damage. Flooding in the area due to excess storm water resulted in claims of property damage of about US\$773 million, and nationally, flood insurance claims more than US\$1.9 billion per year,¹²⁴ demonstrating the potential of IoT to enable better deployment of sustainable finance.

BOX 12: OTHER EXAMPLES OF PRACTICES FROM G20 MEMBERS AND THE PRIVATE SECTOR

Brazil: *The Internet of Things: an Action Plan for Brazil* is a national strategy detailing the policies and action plan for the deployment of IoT technologies.¹²⁵ There is potential to achieve sustainability across the selected focus dimensions: Smart Cities, Healthcare, Agribusiness and Manufacturing. The *Networked Society Lab* was launched in partnership by the federal government and Ericsson to measure the positive impact of IoT projects including smart water, agriculture, rainforest protection, disaster prevention and monitoring applications, which could incentivize greater investment.¹²⁶

Canada: *Bell, BeWhere Technologies and Huawei* have partnered to implement an automated IoT solution for the Henry of Pelham vineyard to help improve planning and sustainability programmes. By using wireless environmental sensors connected to Bell's LTE-M wireless network, the winery will be able to remotely monitor temperature and water levels, and ultimately improve the health of its plants, lowering operating costs and providing for years of maintenance-free data gathering.¹²⁷

China: More than 500 cities are starting their 'smart-city' transformation through IoT, with a scale of related markets to be RMB100 billion (approximately US\$15 billion). In Zhenjiang, "smart dispatch" control for buses reduces carbon dioxide emissions by 6,700 tons and has led to annual fuel savings of US\$2.7 million.¹²⁸ In Xinjiang, the "mobile Internet of Things for Agriculture" project uses wireless monitoring of agricultural greenhouses.¹²⁹

Indonesia: IoT solution supplier *BioMachines* is helping with the sustainable farming of cocoa producers by using a Waspote sensor technology and cloud analytics. The solution gathers environmental data from laboratory and field-based experiments, and enables knowledge transfer to cocoa farmers to improve production in a changing climate. Such data-driven practices can unlock access to finance for farmers.¹³⁰



BOX 12: OTHER EXAMPLES OF PRACTICES FROM G20 MEMBERS AND THE PRIVATE SECTOR (CONTINUED)

Italy: *Telecom Italia*, Italy's largest telecommunications provider, is building a new wireless network for the IoT that should be available nationwide. This creates opportunities to advance sustainable practices. Smart meters for homes and utilities are expected to be among the first devices to be connected in order to improve water and electricity consumption.¹³¹

Japan: The *Sustainable Smart Cities Project* helps to better balance demand and supply side across various sectors, making infrastructure investment more efficient by limiting large-scale investment in the supply side.¹³²

Mexico: Mexico City is using a “Smart grid” system that includes traffic management and incident detection, operating 20,000 sensors and cameras around the city. It has helped reduce electricity theft. Disaster and environmental monitoring are also main drivers of the plan to keep the city smart and to keep supplying data in to make it even smarter.¹³³

Russian Federation: Moscow connected all of its public transport and municipal vehicles into the same platform to monitor their operations, and improve their speed and fuel consumption management.¹³⁴

Turkey: The City of Istanbul has deployed the “Smart Cities” project in partnership with İBB. This project aims to implement IoT technologies to ensure that the needs of both citizens and managers are met more efficiently in areas that involve urban life, such as transportation administration and environment.¹³⁵

US: Using IoT as an enabler, *AT&T* collaborated with *HydroPoint* to create a smart irrigation solution where data from 40,000 weather stations and 8 million daily data points are managed and sent to wireless cellular supported controllers to distribute the right amount of water based on near real-time weather conditions. It also offers near real-time tracing of water depletion and leak recognition.¹³⁶

02.4.3 Digital Technologies Enabling Low-carbon, Resilient Economies

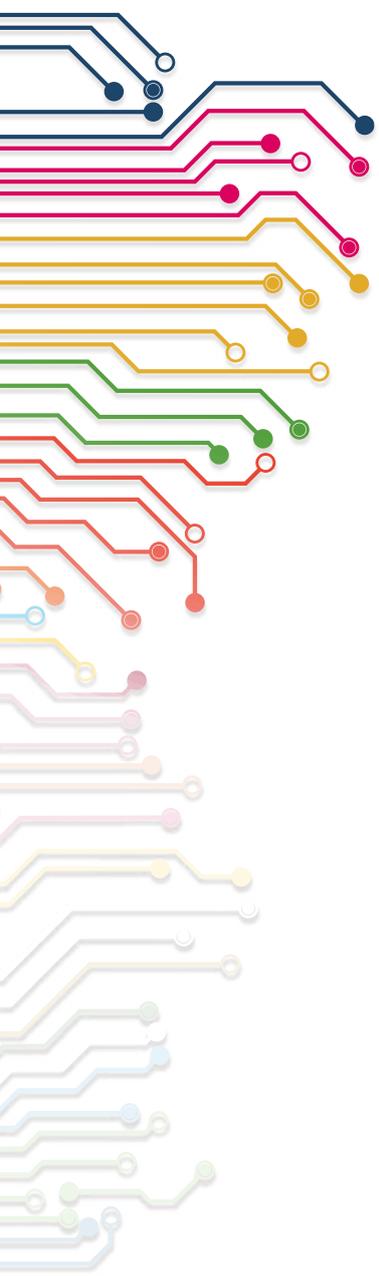
Digital technologies are playing an increasing role in promoting low-carbon, resilient economies. Like in the financial sector, digital technologies enhance the availability, accessibility and accuracy of information to improve water management, agricultural practices and disaster risk management. In the

energy sector, digital technologies are set to make energy systems more connected, intelligent, efficient, reliable and sustainable.¹³⁷ Advances in the way data is generated, analysed, recorded and shared has unlocked a range of applications improving the tracking of greenhouse gas emissions, as well as monitoring, reporting and verification processes. Below are a few illustrative examples from G20 members.

BOX 13: EXAMPLES OF PRACTICES FROM G20 MEMBERS AND THE PRIVATE SECTOR

- *Better information improving water management, agricultural practices and disaster risk management:* In **South Africa**, optimally benefiting from available rainfall requires access to real-time weather information. The South African Weather Service and HydroNET have joined forces to make reliable historical, actual and forecasted rainfall information easily available for water- and weather-sensitive industries. Smart web applications turn weather and water data into valuable maps and graphs enabling better decisions for the sustainable management of South African water resources.¹³⁸ *Grillo*, in **Mexico**, has developed early earthquake warning systems using the big data, machine learning and IoT technologies that can detect earthquakes up to 400km away and process vast streams of ground motion data to determine if an earthquake is happening. This allows alerts to be sent to people up to 2 minutes in advance through a mobile app.¹³⁹
- *Making energy systems more intelligent, efficient and sustainable:* Software platforms and blockchain technology allow for the development of P2P platforms where consumers can both buy and sell clean energy with each other. For example, *Lumenaza* in **Germany** has developed a *new software platform that lets utilities buy and sell “regional electricity” by connecting up small producers with consumers.*¹⁴⁰ In the **US**, the Brooklyn Microgrid project, implemented by *LO3Energy*, operates by allowing residents to generate, store, and commercialize from rooftop solar panels and a conventional power plant via a microgrid enabled by blockchain technology that records transactions at the local level.¹⁴¹
- *Improving tracking and reporting of greenhouse gas emissions reductions and avoidance of double counting:* Blockchain technology has the potential to transparently record, track and report on emission reductions and monitor progress. *Climate Chain*, an open, French-based public research initiative,¹⁴² is exploring and mobilizing the potential of blockchain technology to deliver an efficient, reliable and scalable infrastructure to support the transition to low carbon, resilient economies. It has designed a French Carbon Registry pilot, where the national registry of carbon in **France** is being replicated on the blockchain to study the advantages and disadvantages of building a blockchain infrastructure for managing monitoring, reporting and verification processes at the sovereign level and valuing avoided emissions.

In recognition of the potential of digital and blockchain technologies, particularly with regard to transparency, cost effectiveness and efficiency, the UN Framework Convention on Climate Change (UNFCCC) Secretariat specifically supports initiatives that lead to innovation at the intersection of blockchain and climate, including the ‘Blockchain for Climate’ hackathon organized by the government of Liechtenstein, Cleantech 21, INFRAS and ETH Zurich in the margins of COP23.¹⁴³



03

SUSTAINABLE DIGITAL FINANCE AND THE SDGS

While digital finance is most commonly understood in relation to the SDG targets related to financial inclusion (SDG 8), the mapping of practice across G20 members and the private sector demonstrates how digital finance is helping to achieve a variety of SDGs targets. Table 3 provides examples and highlights evidence of sustainable digital finance's contribution to achieving specific SDG targets as measured in the global SDG indicator framework, developed by the Inter-Agency and Expert Group on SDG Indicators and agreed upon at the 48th session of the United Nations Statistical Commission held in March 2017.¹⁴⁴ Table 3 is illustrative and non-exhaustive, aiming to link sustainable digital finance practices with specific SDG indicators. Hence, examples related to the impact of digital finance

on improving the integration of environmental and social considerations into both active and passive investment decision-making are not included because of challenges in attribution to specific SDG indicators. Table 3 highlights that today, sustainable digital finance is already contributing to 13 out of the 17 SDGs. Mobile technology, followed by MLAI and big data are most prevalent, particularly related to layers three (new sources of sustainable finance) and four (innovations in the financial and real economy) of the pyramid depicted in Figure 1. Further research is needed to assess the potential of current and emerging digital technologies with respect to achievement of the SDGs and measure impact beyond practices related to financial inclusion.

TABLE 3: ILLUSTRATIVE EXAMPLES OF SUSTAINABLE DIGITAL FINANCE'S CONTRIBUTION TO ACHIEVEMENT OF THE SDGS

SDG Goal/indicators	Technology	Pyramid layer	Examples of sustainable digital finance practices and applications
Goal 1. End poverty in all its forms everywhere			
			
1.1.1 Proportion of population below the international poverty line...	Mobile technology; big data, MLAI	New sources of finance; Innovations in the financial and real economy	M-Pesa in Kenya revolutionized financial inclusion through mobile money, which was found to reduce poverty by 2%, particularly among female-headed households. ¹⁴⁵ Alternative lending platforms leveraging P2P and crowdsourcing models, as well as big non-bank technology companies using big data and AI are offering new sources of finance, particularly for SMEs (Box 9). Digital finance unlocks innovative business models in the real economy and improves development of the financial sector, creating new job opportunities, and benefiting poor households. ¹⁴⁶
1.2.1. Proportion of population living below the national poverty line...			
1.2.2. Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions			
1.3.1 Proportion of population covered by social protection floors/systems	Cellular/mobile technology	Innovations in the financial and real economy	India's digitalization of social cash transfers through electronic payments, rather than transfers of cash, creates efficiencies, lowers leakages and reduces corruption. Beneficiaries of digitized cash transfers are much more likely to receive their payments on time and have access to accurate information about government programmes. ¹⁴⁷
1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP)	Blockchain, satellite imagery	Investment decision-making; Innovations in the financial and real economy	Lombard Odier (Switzerland) bought its first catastrophe bond using blockchain-based smart contracts, which automates the payout process when a triggering 'cat' event occurs, increasing liquidity into the cat bond market. ¹⁴⁸ Crédit Agricole Assurance and Airbus (France) are using satellite imagery to calculate precise losses, which allows the development of innovative insurance products for grasslands farmers for the first time (Box 11).
Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture			
			
2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector	Big data, MLAI, mobile technology, IoT	All	Digital finance, notably mobile technology, is contributing to the dramatic increase in investment in 'Agtech', which grew 75% to reach US\$860 million in 2013 and US\$2.36 billion in 2014. ¹⁴⁹ Similarly, it creates opportunities to increase ODA and other official flows to the agricultural sector. For example, Australia Aid, SIDA, the South African Government, UK Aid, and USAID, contribute to the Global Innovation Fund, which invests in innovative solutions leveraging technology in the agriculture value chain. ¹⁵⁰
2.3.2 Average income of small-scale food producers	Mobile technology; blockchain	Investment decision-making; New sources of finance	BEI Fintech Taskforce is testing whether blockchain can help unlock financial incentives that reward sustainability in supply chains for smallholder farmers. If successful, the outcome of the pilot could ultimately benefit the 1.5 billion families who depend on small-scale agriculture worldwide (Box 6). In Malawi, farmers offered digital direct deposits for cash crops experienced a 21% increase in the value of their crop outputs and an 11% increase in household consumption after the harvest. ¹⁵¹
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all			
			
4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills...	All	All	Indirectly, as the digital finance ecosystem and practices grow, so too does the proportion of ICT skills. Incubators and accelerators offer specific technical and business skills development. For example, F10 Incubator and Accelerator in Zurich (Switzerland) offers a programme that includes capacity development on business and technology for start-ups. F10 partners with foraus in collaboration with the Swiss Finance & Technology Association to bring together experts in the areas of finance, tech and sustainable development aimed at developing innovative, sustainable financial services and products. ¹⁵²

TABLE 3: ILLUSTRATIVE EXAMPLES OF SUSTAINABLE DIGITAL FINANCE'S CONTRIBUTION TO ACHIEVEMENT OF THE SDGS (CONTINUED)

SDG Goal/indicators	Technology	Pyramid layer	Examples of sustainable digital finance practices and applications
Goal 5. Achieve gender equality and empower all women and girls 			
5.b.1 Proportion of individuals who own a mobile telephone, by sex	Mobile technology	New sources of finance; Innovations in the financial and real economy	The growth of digital finance applications that contribute to the well-being of households creates incentives and opportunities for individuals, particularly women, to invest in technology. For example, in 2002 Kenya had two mobile phones for every 100 of its 38 million people. As digital infrastructure increased and costs of devices decreased, between 2002 and 2006 the number of mobile phones in Kenya increased from one million to 10 million. M-Pesa was launched in 2007. By 2015 almost 18 million Kenyans had accounts used to pay for education, medicine and transport – handling 20 per cent of Kenyan GDP. ¹⁵³ The rapid expansion of mobile money in Kenya was found to have enabled 185,000 women to move out of subsistence farming and into business or sales occupations. ¹⁵⁴
Goal 6. Ensure availability and sustainable management of water and sanitation for all 			
6.1.1 Proportion of population using safely managed drinking water services	Mobile technology	Innovations in the financial and real economy	Digital payment platforms accessible through mobile phones unlock new business models that increase access basic services. For example, Sarvajal (India) uses mobile payments to enable its customers to pay per use at automated water dispensing units (Box 11).
Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all 			
7.1.2 Proportion of population with primary reliance on clean fuels and technology	Mobile technology; IoT	Innovations in the financial and real economy	Smart technology combined mobile payments enables off grid cleantech companies to serve excluded communities through a pay-for-use model. Examples include Simpa Network (India); M-Kopa Solar (Kenya); Questsol (Guatemala).
7.2.1 Renewable energy share in the total final energy consumption			
7.3.1 Energy intensity measured in terms of primary energy and GDP	Big data, AI, mobile	Investment decision-making	Digital technologies address information asymmetries and lower the costs of capital for financing green commercial loans, including for energy efficient modifications. One example is ING Real Estate Finance (Netherlands) (Box 5).
Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all 			
8.1.1 Annual growth rate of real GDP per capita	All	All	It is estimated that digital financial services can add US\$3.7 trillion to the GDP of emerging economies. ¹⁵⁵
8.2.1 Annual growth rate of real GDP per employed person			
8.4.1 Material footprint, material footprint per capita, and material footprint per GDP	Big data, AI, mobile technology, IoT	Incentivizing sustainable choices	Digital technologies provide transparency around the environmental impact of consumption choices. For example, the Ant Forest Programme (China) greens citizen consumption patterns by translating financial transaction data into individual carbon accounts, and incentivizing users to choose low-carbon activities.
8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP			
8.5.2 Unemployment rate, by sex, age and persons with disabilities	All	All	It is estimated that digital financial services can add 95 million additional jobs in emerging economies. ¹⁵⁶
8.10.2 Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider	Mobile technology	New sources of finance	Digital financial services can turn 1.6 billion of the 2 billion unbanked people into formal financial customers by 2025. ¹⁵⁷ M-Pesa has helped to increase financial inclusion in Kenya – in 2006, 20% of the adult population was banked; by 2013, 67% had some kind of access to financial services. ¹⁵⁸

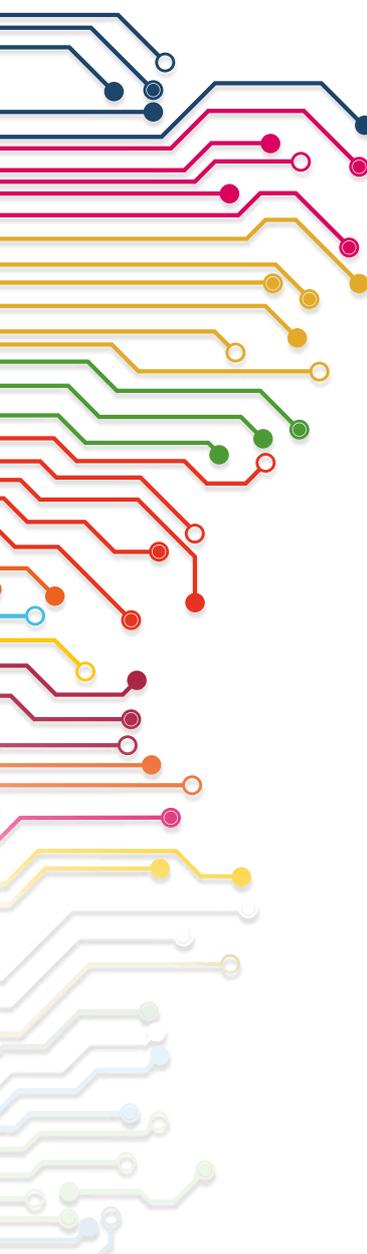
TABLE 3: ILLUSTRATIVE EXAMPLES OF SUSTAINABLE DIGITAL FINANCE'S CONTRIBUTION TO ACHIEVEMENT OF THE SDGS (CONTINUED)

SDG Goal/indicators	Technology	Pyramid layer	Examples of sustainable digital finance practices and applications
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation			
			
9.1.1 Proportion of the rural population who live within 2 km of an all-season road	Mobile technology	New sources of finance	M-Akiba is a first of its kind, mobile technology-enabled retail bond issued by the Kenyan government. Launched in 2015, it has a three-year tenure, pays an annual coupon rate of 10 per cent, and the proceeds will be used to finance infrastructure projects. The bond can be purchased through a mobile phone (which does not need to be a smartphone), which allows citizens living in the remote parts of Kenya to trade government bonds, without having to travel long distances to the major cities to initiate the purchase and follow up on payments. ¹⁵⁹
9.3.2 Proportion of small-scale industries with a loan or line of credit	Mobile technology; big data, AI	New sources of finance	Alternative lending platforms leveraging P2P and crowdsourcing models, as well as big non-bank technology companies using big data and AI are offering new sources of finance, particularly for SMEs (Box 9).
9.b.1 Proportion of medium and high-tech industry value added in total value added	Mobile/online technology; AI	New sources of finance	Matchmaking platforms offer a combination of curated deal flow to match investors with credible investment opportunities (Box 10).
Goal 10. Reduce inequality within and among countries			
			
10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population	All	All	Moody's reported that between 2008 and 2012, greater usage of digital payments added US\$983 billion in global economic growth, which is the equivalent to creating 1.9 million jobs. ¹⁶⁰
10.c.1 Remittance costs as a proportion of the amount remitted	Mobile technology	Innovations in the financial and real economy	Digital technology, notably mobile is reducing remittance costs. For example, sending money overseas with Xoom/PayPal costs on average 3.93% of the amount sent compared with World Bank data demonstrating that the average cost of sending a remittance is 7.45%. ¹⁶¹
Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable			
			
11.2.1 Proportion of population that has convenient access to public transport...	Mobile, IoT	Innovations in the financial and real economy	Payment platforms via mobile technology and over the Internet have played a critical role in unlocking business models for the circular and sharing economy. This has, in turn, changed the demand for public transport, including through the rising popularity of bike-sharing services. For example, Jump Bike pioneered dockless bike share in 2010, which helped solve the last-mile issue for many riders. The company later started introducing electric bikes. Jump Bike deploys 15,000 bikes in 40 markets across six countries. ¹⁶²
11.4.1 Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage...	Mobile/online platforms	New sources of finance	Crowdfunding and P2P platforms unlock new sources of finance for environmental and social causes (Box 9).
Goal 12. Ensure sustainable consumption and production patterns			
			
12.2.1 Material footprint, material footprint per capita, and material footprint per GDP	Big data, AI, mobile technology, IoT	Incentivizing sustainable choices	Digital technologies provide transparency around the environmental impact of consumption choices (Section 2.2).
12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP			

TABLE 3: ILLUSTRATIVE EXAMPLES OF SUSTAINABLE DIGITAL FINANCE'S CONTRIBUTION TO ACHIEVEMENT OF THE SDGS (CONTINUED)

SDG Goal/indicators	Technology	Pyramid layer	Examples of sustainable digital finance practices and applications
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels 			
16.5.1 Proportion of persons who had at least one contact with a public official and who paid a bribe to a public official, or were asked for a bribe by those public officials, during the previous 12 months	Mobile technology	Innovations in the financial and real economy	Digital payments increase transparency and security by increasing accountability and tracking, reducing corruption and theft. When the Indian government made social security pension payments through digital smart cards instead of manual cash payouts at the village level, there was a 47 per cent reduction in bribe demands and the incidence of ghost recipients fell by 1.1 percentage points. ¹⁶³
16.5.2 Proportion of businesses that had at least one contact with a public official and that paid a bribe to a public official, or were asked for a bribe by those public officials during the previous 12 months			
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development 			
17.3.1 Foreign direct investment (FDI), official development assistance and South-South cooperation as a proportion of total domestic budget			While not specific to sustainable digital finance, fintech in general has been found to increase FDI. For example, in the UK, research by EY (2016) showed that fintech has helped push FDI to its highest level since 2006 – 94 FDI projects in the UK's financial services sector, which in turn generated 8,138 jobs in 2015. ¹⁶⁴
17.3.2 Volume of remittances (in United States dollars) as a proportion of total GDP			In Mexico, there is evidence that digital accounts opened through a social transfer programme increased the frequency of remittances received through formal payment channels. ¹⁶⁵
17.1.1 Amount of United States dollars committed to (a) public-private partnerships and (b) civil society partnerships	All	All	Sustainable digital finance applications create new opportunities for public-private and civil society partnerships. For example, the Sustainable Digital Finance Alliance is a public-private partnership recently co-founded by the UN Environment and Ant Financial Services to harness the potential of digital finance for sustainable development. ¹⁶⁶





04

IMPLICATIONS AND UNINTENDED CONSEQUENCES

The mapping of practice across G20 members and the private sector reveal three problems – digital finance’s ‘data power’ is under-leveraged by the financial sector, its ‘innovation power’ is small scale, and it creates unintended consequences.

The first implication is that digital finance’s **‘data power’** is under-leveraged by the financial sector to increase sustainable investments. The most widely adopted and mainstream technologies in the financial sector are big data, AI and automation on the back-end, allowing for significant increases in the availability and accessibility of accurate, low-cost information. However, the extent to which the data unlocked is applied to overcome informational asymmetries and maturity mismatches is limited. This raises the question about how digital technologies (notably big data, MLAI and associated applications) can be more widely mainstreamed by the financial sector to increase investment in more sustainable outcomes.

The second implication is that digital finance’s **‘innovation power’** has not been exploited at large scale in sustainable

development areas yet, making capital deployment in these sectors relatively small. There is certainly excitement around the potential of these new technologies, though there is also scepticism about their robustness to address global sustainable finance issues at scale. This raises the question about how the real economy can better leverage digital finance to drive innovation that makes investments in sustainable business models, sectors and outcomes more viable at scale.

A third implication is that digital finance blurs the line between sectors and stakeholder groups and creates **economic, social and environmental unintended consequences**.

Economically, digital finance creates trade-offs in certain industries. For example, while investments in certain business models (such as Uber) and ‘smart cities’ will improve efficiencies and make better use of capital, they are likely to create job losses in certain sectors. A 2018 report by the OECD shows that while concerns about ‘massive technological unemployment’ are overblown, automation in certain industries is likely to lead to ‘further polarization of the labour market’.

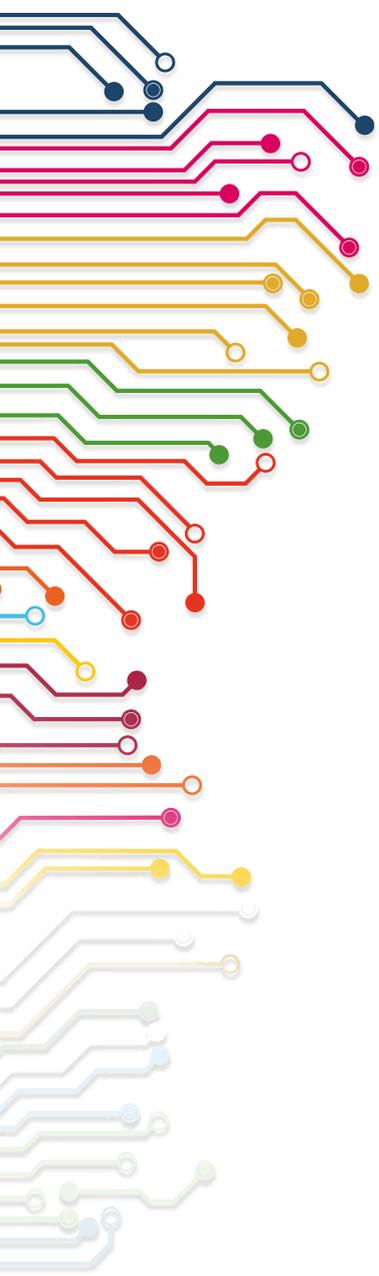
Low-skilled workers and women are most likely to be disproportionately affected by such effects.¹⁶⁷ Hence, while digital finance has the power to increase inclusive growth, it could create inequalities both between and within countries, if not appropriately managed.

In the insurance sector, big data, MLAI and IoT also give insurers a more granular risk assessment of micro-segments of risk transfer in their markets. When insurers can buy data from medical and health device providers about activities and exposure of their individual clients, the risk of a person or a population becoming uninsurable becomes real. This scenario also applies to biophysical risks of climate change impacts in cities, energy and water resource provisioning and in agriculture.¹⁶⁸

Socially, the complexities and downsides related to vast amounts of consumer data are beginning to surface. The explosion of online platforms, including for financial services, social networks and email providers raises questions related to the use and protection of consumer data. Pentland (2013) suggested a 'New Deal on Data' to achieve a data-driven society that ensures that the data needed for public goods are available, while at the same time ensuring citizen protection. Such a 'New Deal' requires the treatment of data as an asset, where individuals have ownership rights over one's own data.¹⁶⁹ Data breaches are creating growing calls for greater digital and data protection and more consumer education.¹⁷⁰ The EU's General Data Protection Regulation (applicable from May 2018), which offers safeguards for the protection

of personal data and the integrity of the EU financial system against money laundering and terrorism finance, must be complied with by a technology-enabled EU financial marketplace.¹⁷¹ Services offered by the private sector are emerging to inform consumers if they have been involved in data breaches.¹⁷² Financial transaction data is also being used to rate social behaviour.¹⁷³ Fuelled with vast amounts of data, concerns are arising around the safety, fairness and trustworthiness of AI.¹⁷⁴ Bias in algorithms that make increasingly important decisions affecting people's livelihoods, including access to finance, could have serious negative consequences and increase exclusion, especially for poorer communities, minorities and women. As the technology becomes more sophisticated, rooting out such biases becomes more difficult. Policymakers are responding to calls for transparency standards and making AI less inscrutable. In December 2017, New York City passed a bill calling for transparency from all AI used across their array of city services. In 2018, under its General Data Protection Regulation, the EU may require any company to be able to explain a decision made by one of its algorithms.¹⁷⁵

Digital technologies also have environmental effects through their hardware and software production, use and termination. Hardware production requires a combination of natural resources including cobalt and lithium, and reports have pointed to the ecosystem degradation and water requirements of such mining operations. High energy consumption is of particular concern. With data centres as

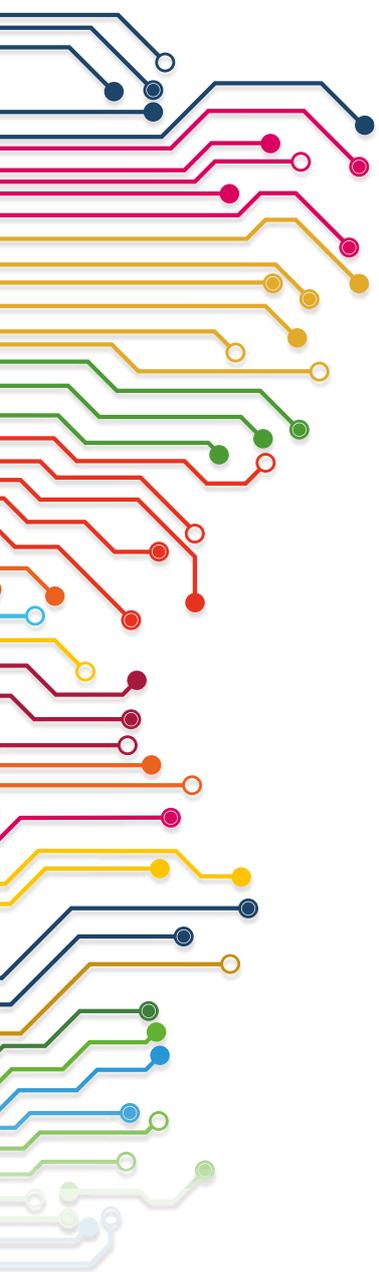


the backbone of the Internet, it has been estimated that global data centres have an annual carbon footprint equal to, if not greater than, the airline industry, with experts predicting that the demand for and from data centres is likely to triple in the coming decade. While ‘smart’ devices may promise increased home energy efficiency, recent research suggests that these devices may increase energy and data centre demand.¹⁷⁶ Similarly, blockchain’s energy footprint is enormous. Mark Carney, Governor of the Bank of England, cited estimates of up to 52TWh for bitcoin mining – double the electricity consumption of

Scotland.¹⁷⁷ New, more energy-efficient protocols are emerging. However, the robustness of these solutions remains to be seen.

Some G20 member countries have responded to the environmental challenges of digital technologies by developing ‘green electronics’ procurement systems and e-waste regulations and management systems. For example, the EU has adopted two Directives to deal with e-waste, while in the UK, data centres are subject to a levy, and in 2014, were offered a reduction in, or exemption from, carbon taxes if certain efficiency targets were met.¹⁷⁸





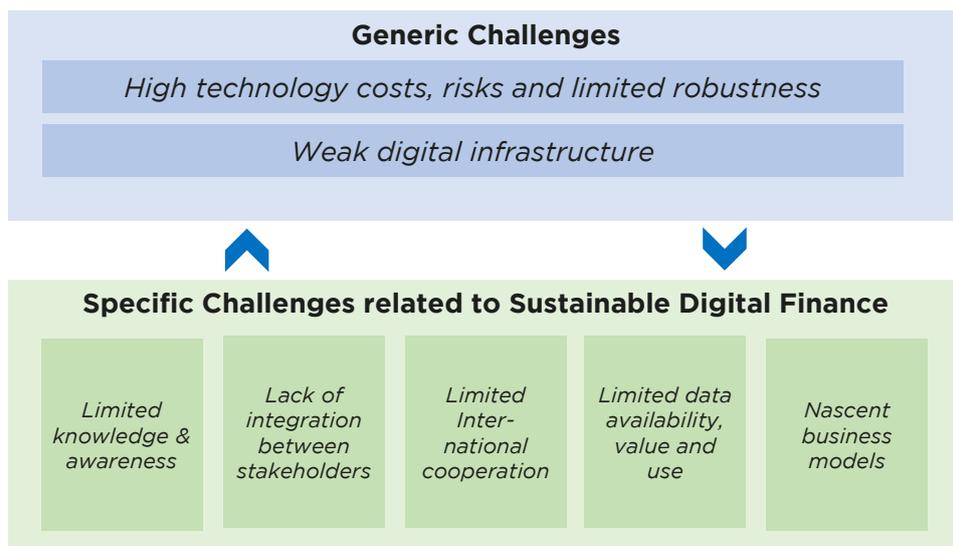
05

CHALLENGES TO LEVERAGING THE FULL POTENTIAL OF SUSTAINABLE DIGITAL FINANCE

Underlying the three implications highlighted in Section 4 are generic challenges that are not unique to sustainable finance, as well as challenges that are specific to sustainable digital finance (Figure 4). The main generic challenges relate to weak digital infrastructure and the costs, risks and robustness related to the technologies. Addressing this layer is ‘necessary but not sufficient’. Specific challenges include limited

understanding of sustainable digital finance, silos between stakeholder groups, little international cooperation on cross-border risks and opportunities, limited value and use of sustainability data for financial decision-making, and weak sustainable business models. Leveraging the full potential of digital finance to enhance the mobilization of sustainable finance requires action by multiple actors across all these challenges.

FIGURE 4: CHALLENGES LIMITING THE FULL POTENTIAL OF SUSTAINABLE DIGITAL FINANCE



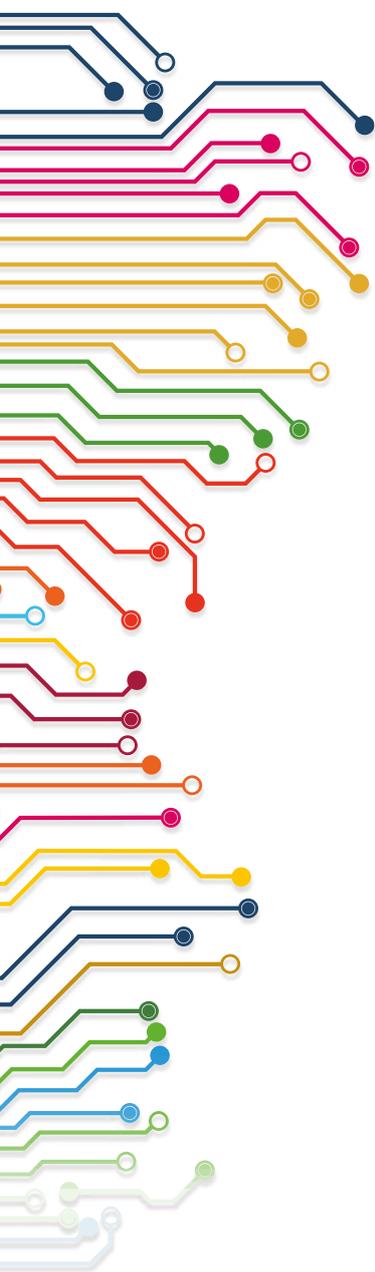
Generic Challenges

- *Weak Digital Infrastructure:* Low-cost and reliable broadband connectivity enables benefits from digital finance to be realized, notably with regard to cloud computing. Connectivity problems also limit the potential of IoT sensor networks to collect data that could unlock more sustainable finance products, such as low-cost weather index insurances.¹⁷⁹ Similarly, while financial institutions have made significant progress in terms of digitizing back-office functions, large financial institutions continue to run their core systems on legacy IT infrastructure that is expensive to maintain and that impedes institutions' ability to have unified view of data across silos. The costs and operational risks of replacing legacy systems and upgrading to new technology solutions are high and some new technologies, as blockchain, do not currently easily integrate with other ordinary business workflows and platforms.
- *High technology costs, risks and limited robustness:* Technologies such as blockchain and IoT are still in proof of concept stage. High and escalating costs of reaching consensus in bitcoin-like networks will be a barrier for adoption.¹⁸⁰ Similarly, the lack of standards to ensure interoperability between systems also limits the adoption of new technologies. Throughput capacity for blockchains is very small (10 transactions per second versus Visa's 40,000 transactions per second)¹⁸¹ and networks operate in isolation, running different consensus

protocols. Deeper analysis of experiences will be needed on a global scale, particularly to better understand medium- and longer-term risks and costs compared with shorter-term benefits. At the same time, as the number of devices connected to the Internet scale, so will the potential of cyber risks, which undermine confidence and financial stability.

Specific Challenges Related to Sustainable Digital Finance

- *Limited knowledge and awareness:* Given the relatively new nature of sustainable finance, and the fast-changing world of digital technologies, research that teases out the full potential and risks of sustainable digital finance is still in its early stages. The combination of sustainable finance, which is relatively new, with digital finance, which is rapidly changing, creates gaps in understanding the nexus between the two areas. While levels of sustainable finance are increasing, it is still small compared with mainstream investments in capital markets. Digital finance is not seen by mainstream financial actors as a tool that has the potential to scale up sustainable finance by improving the risk/return profile of sustainable investments.
- *Lack of integration between stakeholder groups and agendas:* Sustainable finance and development communities at the national and international levels are largely separated from digital technology players. Similarly, policymakers and regulators tend to treat sustainable finance, inclusive development and



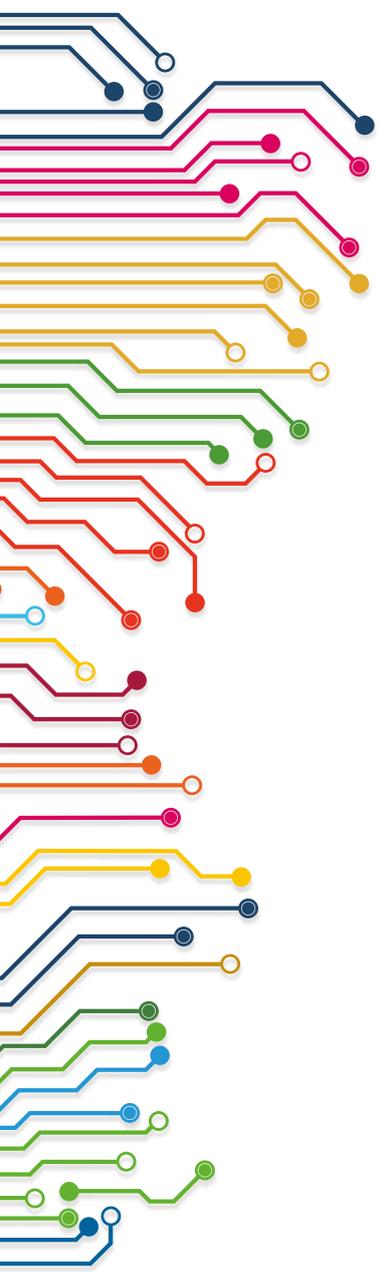
digital technologies as distinct areas, resulting in separate government plans to promote sustainable finance on the one hand, and digital finance or fintech on the other. This makes it difficult to see second-order opportunities and unintended consequences that arise from the inherent interconnectedness of these agendas. The financial inclusion agenda is also seen as distinct from the broader sustainable finance agenda, and the role of digital technologies is largely limited to improve access to financial services. This creates missed opportunities for digitally enabled co-benefits between financial inclusion and sustainable finance.

- *Limited international cooperation:* Most sustainable digital finance pilots and sandboxes focus on the country level. This makes sense at the beginning. However, given the inherent cross-border nature of digital finance, there is an important role for international cooperation in addressing some of the key challenges and risks in this area. There are also great opportunities for cross-country learning and scaling successful pilots across regions.
- *Limited availability, value and use of sustainability-related data for financial decision-making:* The effectiveness of digital finance to leverage data (including PAED) to reduce information asymmetries, improve analytical capacities for better sustainable investment decision, and unlock new sources of lending to sustainable SMEs depends on the existence of large data

sets, notably of environmental performance data. It also depends on awareness and value placed on using such data for sustainable finance investment decisions. Even where data sets may be in place, and value placed on using data to increase investments in sustainable outcomes, adopting digital finance to overcome sustainable finance barriers may be slow due to the lack of standards and methodologies related to translating behavioural data into environmental performance data. There are also costs to adoption and limited capabilities to understand and analyse such data.

- *Nascent business models and markets:* Many sustainable technology providers currently testing and creating solutions are start-ups, which have higher failure risks. Business models and markets are new and there is uncertainty as to what works and what does not. Since sustainable digital solutions are relatively new, they face difficulties in accessing funds because they are not seen or categorized as 'green' products and cannot respond to key fund performance indicators (such as reduction in greenhouse gas). For larger market players, sustainable IoT implementation comes from company 'innovation' budgets, and it will take time before they mainstream into larger business budgets to convert these into large-scale deployments.¹⁸² Incumbents in some markets may increase market entry costs for sustainable digital finance solutions.





06

EMERGING OPPORTUNITIES

Digital finance is blurring the line between sectors and stakeholder groups, creating a need to redefine these borders in a certain capacity. Innovative multiparty engagement platforms are emerging at the national and international levels, allowing stakeholders to coordinate, sequence and measure the appropriate new system-wide protocols and regulations across a network of institutions and practice; as well as to share best practices, experiences, cost-benefit analysis and to consider unintended consequences of implementation. The practice of G20 mapping highlights the growing appreciation of the value of multiparty collaboration and knowledge-sharing at the national and international level, and suggests a number of opportunities to move the sustainable digital finance agenda forward. Some of these practices and the pathways they are creating for change are highlighted below. Based on these pathways, Box 14 suggests concrete opportunities for action at the national, regional and international levels.

1. Addressing Elements of Generic Challenges:

- *Digital infrastructure:* Enhancing digital infrastructure is a key priority, particularly in emerging

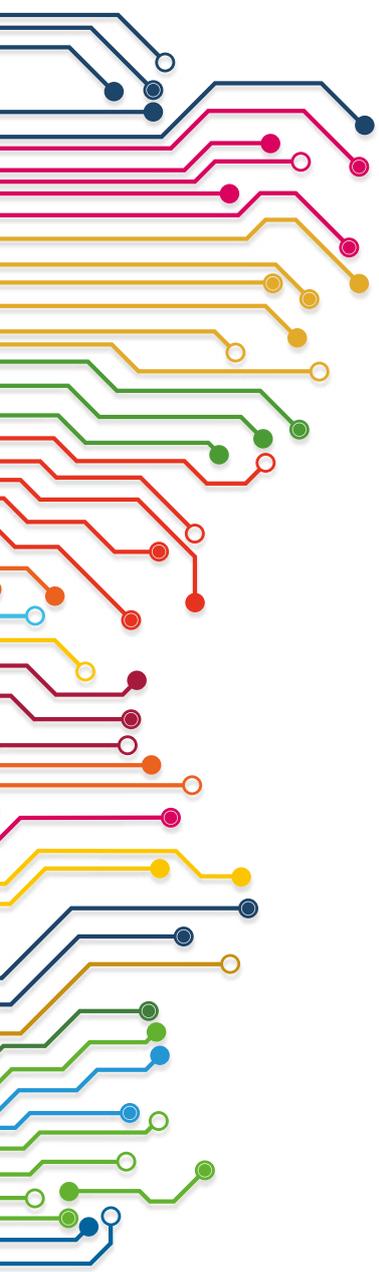
markets, and will require significant financing from both public and private sources. The power of digital finance to unlock new business markets makes investments in digital infrastructure more attractive, and helps facilitate public-private partnerships in this regard.

- *Technology:* G20 members and the private sector are continuing to research and further develop new technologies in order to improve their scalability and reduce costs. For example, *Climate Chain*, open, French-based public research initiative¹⁸³ is carrying out research on ‘responsible blockchain’ to mitigate the carbon intensity of the blockchain through alternative protocols. More energy-efficient blockchain solutions are emerging. *Ethereum* plans to change its algorithm to an energy efficient proof-of-stake algorithm that would minimize energy consumption and *Datamatics*¹⁸⁴ in **India** uses a blockchain platform, BigchainDB with a limited validation rather than full consensus process to lower energy costs. The BigchainDB also enhances the performance of the blockchain from a few tens of transactions per second, to up to a million.

In **Canada**, *Myera Group*¹⁸⁵ uses waste heat from bitcoin mining to power greenhouse production and fish farm, and *Kontrol Energy Corp*¹⁸⁶ is planning to power P2P sustainable energy market with the use of blockchain. **South Korea's** *SK Telecom* has launched its first commercial, low-cost IoT network, using technology that will let it access 99% of the country's population. It will ease the cost of IoT platform for start-ups, small- and medium-sized firms.¹⁸⁷ Coordinated approaches are also emerging to develop standards to promote interoperability between systems. The **European Commission's** new Fintech Action Plan envisages the development of more coordinated approaches on standards for fintech by liaising and working with major standard-setting bodies, such as European Committee for Standardisation and International Organization for Standardization including in the blockchain area.¹⁸⁸

2. Raising Awareness about the Potential, Opportunities and Risk of the Application of Digital Technologies to Sustainable Finance

- *Research and learning:* Further study of the potential of sustainable digital finance is important to build understanding and awareness on opportunities and benefits as well as to uncover risks and unintended consequences. Breaking down the sustainable digital finance agenda can help generate more granular findings and respond to the needs of various stakeholder groups. For example, a deeper understanding about how digital finance can be used by the
- banking sector to better analyse environmental risks would make it easier for banks to adopt such practices. The Central Bank of **Mexico** is currently studying how environmental risk analysis and financial decision-making can be improved through PAED and digital technologies. This research will help regulators better leverage digital technologies and PAED to more effectively support the transition to a lower-carbon economy.
- *Multi-stakeholder engagement platforms:* The interconnected nature of digital finance creates multiple opportunities to bring together different groups to raise awareness about the potential of sustainable digital finance solutions and to address common challenges. The financial sector, policymakers, sustainable development experts and the fintech community could be convened to look at national or regional sustainable finance strategies through a digital finance lens and fintech strategies through a sustainable finance lens. For example, in **Switzerland**, the Ministry of Finance recently convened a roundtable that brought together for the first time the fintech and sustainable finance communities to better understand how digital finance can support the Swiss sustainable finance agenda. The IFC and the Monetary Authority of **Singapore** have established an Association of Southeast Asian Nations (ASEAN) Financial Innovation Network (AFIN) in order to encourage fintech innovation in Asia. AFIN will help financial institutions, financial technology firms and regulators in the ASEAN region



address issues of cross-border compatibility in the region. AFIN may create an industry ‘sandbox’ to provide a cloud-based testing environment through which banks and financial technology players can develop, test and refine digital finance and inclusion solutions.¹⁸⁹ Similarly, the Stockholm Green Digital Finance Centre in **Sweden** was launched at the G20 GreenInvest meeting in May 2017 to promote collaborations between companies, regulators and financial centres aimed at supporting the acceleration of sustainable finance.¹⁹⁰ **Mexico’s** new Fintech Law allows for the creation of a financial innovation group – a multi-stakeholder consultative mechanism to advise on regulation.¹⁹¹ These convening efforts can also help overcome other sustainable finance challenges not necessarily related to the digital agenda.

- *International cooperation:* International fora including the **G20** and the **United Nations** could promote cross-border sharing to help scale best practices in the area of sustainable digital finance. The United Nations Secretary-General has mandated a Task Force on Digital Finance for the SDGs to look specifically at the role of digital technologies for enhancing finance for the SDGs. Work at the international level would create the high-level visibility needed to engage industry players, particularly large multinationals with inherent capacity to scale, and small innovative companies. International multi-stakeholder platforms could promote cross-border sharing, identify new

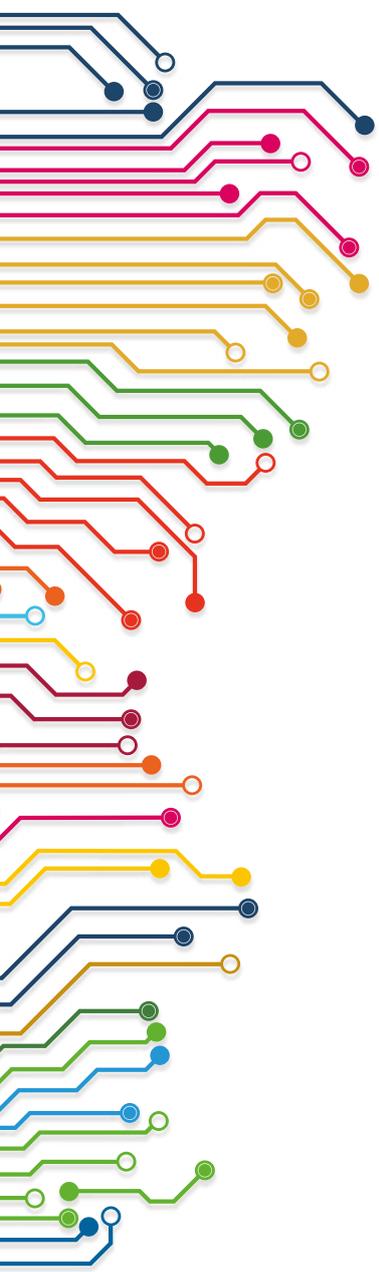
opportunities to develop and deploy sustainable digital finance solutions and scale best practice pilots across countries. Such platforms would also be better equipped to link environmental research mitigating the carbon intensity of the blockchain with innovative pilots leveraging blockchain to enhance the mobilization of sustainable finance. International networks of regulators could play a valuable role in this regard by reviewing key issues, including those related to interoperability and standards.

3. Encourage Investment in Digital Technologies That Advance Sustainable Finance

- *Encourage the integration of sustainability elements into the existing fintech ecosystem:* Creating competitions, hackathons, incubators and accelerators that focus specifically on crowding in solutions related to sustainable business models, or better integrating sustainability elements into the existing fintech ecosystem would help to crowd in solutions related to sustainable digital finance applications and business models. Strengthening collaboration and knowledge-sharing between sustainable start-ups could also reduce risks and strengthen business models, improving the likelihood of success and scale.
- *Improve the visibility and the transparency of new sustainable digital finance solutions:* The creation of dedicated labels or categories for sustainable digital finance solutions could facilitate the identification of such

solutions, increase awareness about a market for such solutions, improve transparency and enable these solutions to access funding from green or sustainability-focused funds.

- *Define the requirements to scale innovative pilots using blockchain and IoT to address information asymmetries and lower information search costs:* This would enable stakeholders to identify constraints, required partnerships and potential solutions early on, increasing the likelihood of scale, which in turn facilitates uptake by institutional investors. Engaging with IoT stakeholders, notably within the private sector, could help the prioritization of sustainability goals as part of commercial project design to maximize social impact.
- *Develop more standardized tools and instruments:* Currently the methodology for translating financial purchases data into environmental data is limited. In order to support greater adoption of digital finance to scale up sustainable finance, it would be helpful to improve and standardize accounting methodologies for translating a wide range of financial transaction data into environmental performance data. This would help encourage investment in sustainable digital solutions that provide consumers with information about the environmental and social impact of their purchasing decisions. As a result, consumers would find it easier to make well-informed decisions and opt for sustainable choices. It may also include developing accepted definitions and protocols to enable financial institutions to use such methodologies for their investment decisions. Strengthening institutional capacity to use digital technologies and such methodologies in sustainable finance may be needed.
- *Create new sustainable financial products that are easily accessible online and through mobile applications within the applicable legal framework for investment services (e.g. retail sustainable bonds available through mobile phones):* With the number of connected devices expected to increase by over 100% in the next three years to over 20 billion, and citizens (particularly young adults aged 18-34) driving mobile and online commerce behaviour, creating new online/mobile sustainable financial products can increase citizen participation in the sustainable investment value chain.¹⁹²
- *Scale virtual tech platforms that bring together sustainable assets and investors within the applicable rules on trading facilities:* This type of leapfrogging technology could allow emerging markets' banks to renew and refresh their balance sheets to sustainable investors and therefore allow for additional balance sheet capacity to underwrite new sustainable loans. Many young and innovative firms, driven by entrepreneurs, could grow this opportunity, especially if sustainable VC is more widely available. Further, local and federal governments could provide the environment and incentives for these companies to grow and succeed.
- *Foster close interactions between innovative sustainable*



digital finance solutions and regulators/supervisors: This would help ensure that regulation is appropriately on-boarded in their development and life cycle management, as early as possible and throughout. A level playing field has to be assured (same risks, same rules). Existing mechanisms could be leveraged to achieve such interactions. Where regulatory sandboxes do exist, including sustainability considerations into the selection criteria may be considered. Opportunities provided by fintech laws and regulations could be leveraged to incorporate

principles of sustainable finance. For example, **Mexico** may use the opportunity of its new Fintech Law to include issues around sustainability through secondary regulation. This would be an innovative approach to bringing the digital finance and sustainable development agendas more closely together. Emerging multiparty networks, fintech hubs and sandboxes could include a specific focus on accelerating digital finance solutions that promote sustainable investment. This could help work through issues and promote standards to improve interoperability.

BOX 14: OPPORTUNITIES FOR ACTION

The challenges and opportunities highlighted in Sections 5 and 6 point to specific actions that could be undertaken to better leverage the power of digital finance to enhance the mobilization of sustainable finance.

A Research Agenda:

The combination of sustainable finance, which is relatively new, with digital finance, which is rapidly changing, creates gaps in understanding the nexus between the two areas. This highlights the need for further research to strengthen knowledge, raise awareness and inform action to take the potential of sustainable digital finance to scale. Below are suggested, non-exhaustive research questions:

- *How can digital technologies help financial institutions better identify, analyse and integrate environmental and social risks into financial decision-making?*
- *How can financial centres leverage digital finance to improve sustainability?*
- *How can digital finance transform the future of sustainable infrastructure financing?*
- *How can digital technologies accelerate achievements of each SDG?*

Multi-stakeholder Engagement Platforms:

Establishing a platform at the national or regional level that brings together the financial sector, policymakers, sustainable development experts and the fintech community can contribute to improve engagement on sustainable digital finance and create a centre of gravity. Such a platform could convene various actors to look at

BOX 14: OPPORTUNITIES FOR ACTION (CONTINUED)

national (or regional) sustainable finance strategies from a digital finance lens; identify country (or regional) specific challenges and opportunities, and define what it would take by various stakeholder groups to address local challenges and fully leverage the power of digital finance for sustainable development.

As a centre of gravity, such a platform would also better facilitate engagement with regulators and policymakers around the aspects of digital finance as these relate to sustainability. Specific work streams within national platforms could catalyse dynamic forces for change. For example, a 'green bond tech' task force could enable green bond issuers to join forces with big data, AI and blockchain experts to identify opportunities for technology to reduce costs and scale green bonds. National platforms would also be able to raise awareness about the value of environmental data and increase demands by citizens for greater integration of sustainability considerations into investment decisions by pension funds, asset managers and banks. As a number of national platforms emerge, a network could be created to improve cross-border learning and sharing.

Country Action:

In addition to national sustainable digital finance platforms, specific action at the country level may include:

- Incorporating into existing regulatory sandboxes criteria that encourage the development of sustainable digital finance solutions. Sandboxes that provide an environment where fintechs and financial players can develop and test sustainable digital finance solutions will help catalyse investment in these areas with a pathway to scale. Regulatory sandboxes can also help address adoption challenges around data by developing standards, methodologies and protocols for translating behavioural data into environmental performance data.
- Creating competitions, hackathons, incubators and accelerators that focus specifically on crowding in solutions related to sustainable business models, or better integrating sustainability elements into the existing ecosystem.

International Cooperation:

Continuing the momentum created by the G20 SFSG on the topic of sustainable digital finance would be helpful to move the agenda forward. Taskforces within international forums and specific international networks (e.g. networks of regulators) would be particularly helpful to address cross-border challenges, risks and opportunities in this area. Such a collaboration would create opportunities for sharing experiences and sustainable digital finance pilots across countries, which would help scale current small-scale initiatives.

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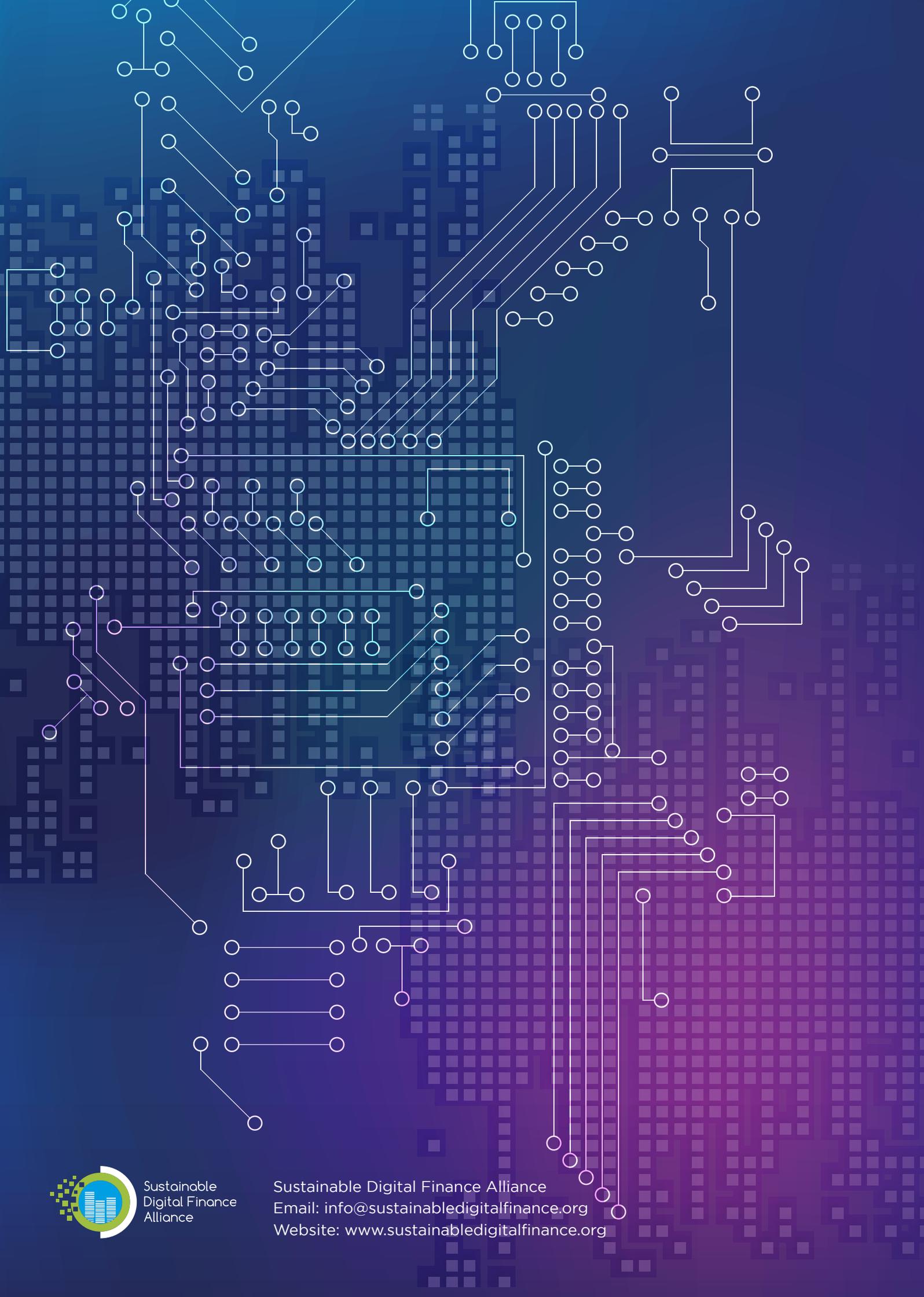
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