



Financing Climate Futures

RETHINKING INFRASTRUCTURE

Digital Finance and Citizen Action

In Financing the Future of Climate-smart Infrastructure



February 2019

The UN Environment Inquiry

The Inquiry into the Design of a Sustainable Financial System was initiated by the United Nations Environment Programme (UN Environment) to advance options to improve the financial system's effectiveness in mobilizing capital towards a green and inclusive economy—in other words, sustainable development. Established in January 2014, it has published three editions of its global, landmark report: the first in October 2015, the second in October 2016, and the third in October 2017. It published its final, global report in April 2018.

More information on the Inquiry is at: www.unepinquiry.org or from: Ms. Mahenau Agha, Director of Outreach mahenau.gha@un.org.

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 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

The opinions expressed and arguments employed in this paper are the sole responsibility of the authors and do not necessarily represent those of UN Environment.

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Executive Summary

In the IPCC's October 2018 Global Warming of 1.5 °C Report, the world's leading climate science body warned that we have until 2030 to take the action needed to avoid the worst impacts of climate change. To get there, we need sweeping changes in how we organize our economies and do business.

Major opportunities for climate mitigation and adaptation lie in the shift to climate-smart infrastructure, as laid out in the 2018 report *Financing Climate Futures – Rethinking Infrastructure*, produced by the OECD, UN Environment and the World Bank.

This report shows that limiting warming to 1.5°C will involve “annual average investment needs in the energy system of around US\$2.4 trillion” between 2016 and 2035. Sustainable infrastructure over the coming 15 years will require US\$90 trillion, more than the world's entire current infrastructure stock. Public and private activities, within and outside the G20, are needed to deliver this finance by mainstreaming climate considerations in investment decisions and strategies across the entire financial system.

Citizen engagement can be a driving force for raising finance. If every person on this planet contributed US\$896 annually, for example, we would have the annual investment of US\$6.9 trillion required for low-carbon, climate-resilient infrastructure development up to 2030. While there are many reasons why every person will not be paying that amount annually, the idea highlights the key role of citizens as the ultimate originators, users and beneficiaries of finance and infrastructure.

This report looks at how digital finance technologies, or fintech, can engage citizens as consumers, pension holding investors, co-producers and voters.

How citizens will respond to increasingly dramatic climatic events is uncertain. A younger generation that is more aware and digitally connected across countries may respond more pro-actively – particularly the youth of emerging markets, who display some of the highest fintech adoption rates in the world. Mobile phone subscriptions in low-income countries have risen dramatically in the past 20 years (58.47 subscriptions per 100 persons by 2016), creating a soft infrastructure that brings with it access to mobile accounts, the Internet and the ability to become part of long-distance transactions in the wider economy.

The impact of fintech in engaging citizens in climate-smart infrastructure development can be observed at four levels: **business model innovation, new sources of finance, consumer choice and behaviour and improved systems and data.**

This study presents many case examples of innovations that are already changing consumer-citizen behaviour at each level, increasing finance for climate-smart infrastructure and reducing emissions, while also issuing key finding and recommendations to increase the scale and impact of fintech. These are summarized as follows:

Business model innovation

Sharing, circular and service-intensive business models are especially adept at engaging citizens. Yet, imperfectly open markets tied to dominant incumbent industries and old conventions restrain the growth of entrepreneurial start-ups in fintech and climate-smart infrastructure development. Market reform, decentralization and improved competition need to be advanced, benefiting from the ability of digital innovation to reduce transaction costs, diversify competition, and facilitate improved coordination as well as accountable governance.

New sources of finance

New markets in distributed clean energy systems provide examples of citizen engagement. These include micro-grids in urban neighbourhoods and pay-as-you-go solar models in rural communities. Getting to scale, beyond ad hoc crowd contributions, is hampered by the lack of capacity to initiate new markets and connect entrepreneurs with larger institutions. City authorities could sharpen their role in creating supportive ecosystems, developing integrated strategies that include climate-smart fintech incubators, service intermediaries, co-finance partnerships to deal with upfront costs, as well as participatory planning and budgeting processes.

Consumer choice and behaviour

Fintech innovations are helping to offer consumers a wider range of choice in areas such as household insurance, home equipment, water and sanitation, waste management, agrifood supplies and urban mobility. Yet citizens, like investors, have behavioural bias, distracted by the seeming complexity of climate-smart infrastructure as asset class. Overcoming behavioural bias can be achieved through innovations in online learning, peer platforms and gamification, tools that provide education and incentives for change.

Improved systems and data

Fintech enables citizens and investors to access more relevant data on climate-smart infrastructure. Yet the fragmented infrastructure industries suffer from barriers in the form of outdated standards and complex organization, which among others result in high resource and carbon intensity, as well as proneness to bribery and corruption. Regulatory and professional bodies need to address this through the development of improved standards and relevant labels that signpost recognized climate standards, as well as use of digital financial technologies for improved transparency and accountability.

1 Introduction

1.1 Why this study?

In October 2018, the IPCC's Global Warming of 1.5 °C Report¹ warned that we have until 2030 to stem catastrophic climate change. The 1.5 °C global warming scenario laid out in the report requires sweeping changes, among them phasing out coal, shifting to renewable energy, and making global infrastructure climate-smart.

Under the 2017 G20 German Presidency, leaders had already recognized this urgent need for accelerated climate change action. They invited the OECD, UN Environment and the World Bank to assess how to public and private activities within the G20 can bring the finance required to meet the Paris goals. These organizations, in association with the German Government, established the “Financing Climate Futures” initiative in response. In 2018, the initiative published *Financing Climate Futures – Rethinking Infrastructure*, which emphasizes the need to mainstream climate considerations in investment decisions and strategies across the entire financial system.

Limiting warming to 1.5°C will involve “annual average investment needs in the energy system of around US\$2.4 trillion” between 2016 and 2035. Sustainable infrastructure over the coming 15 years will require US\$90 trillion, more than the world’s entire current infrastructure stock. Progress has been made in increasing flows of capital towards low-carbon, climate-resilient investments, yet it remains inadequate.²

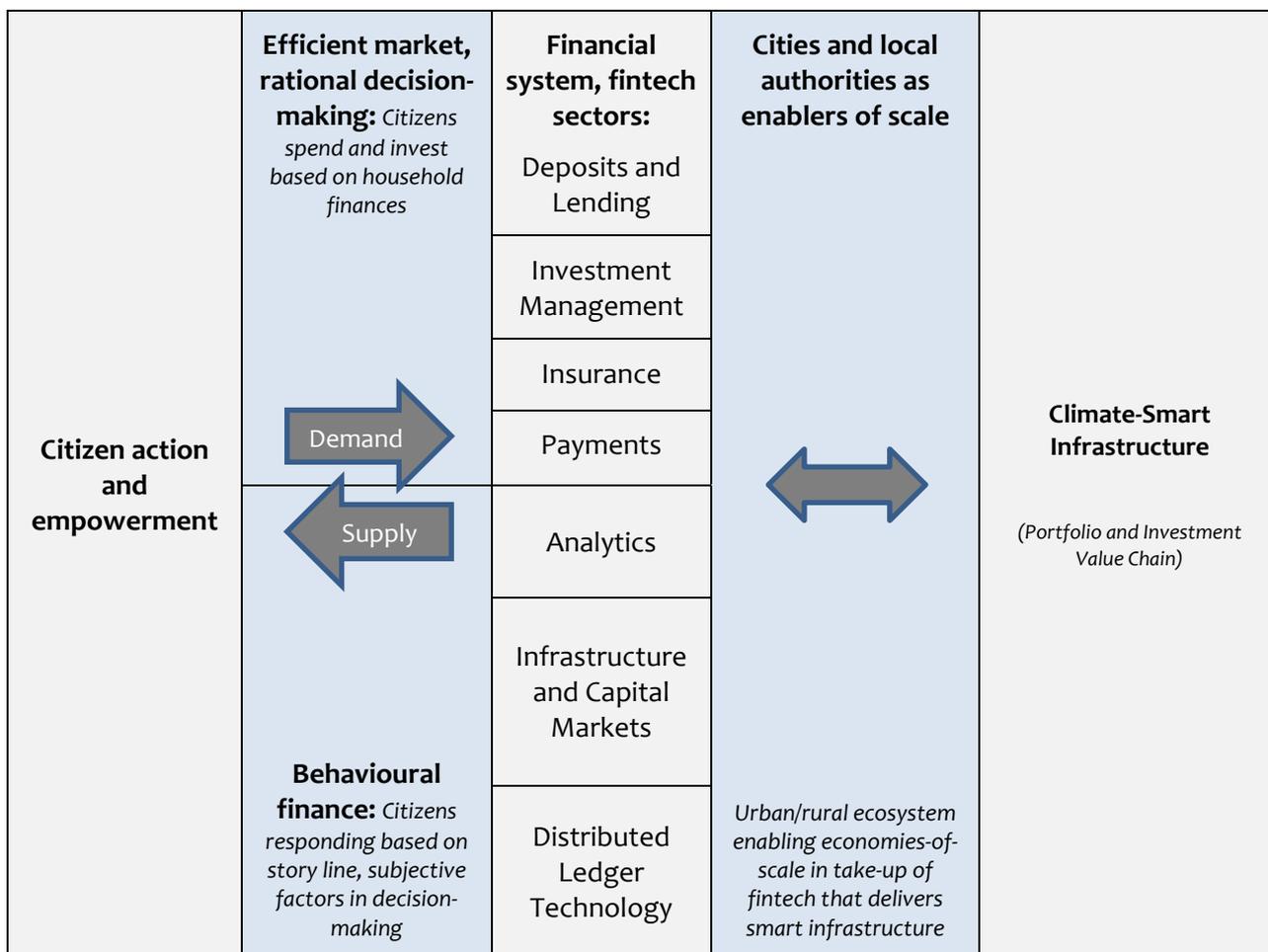
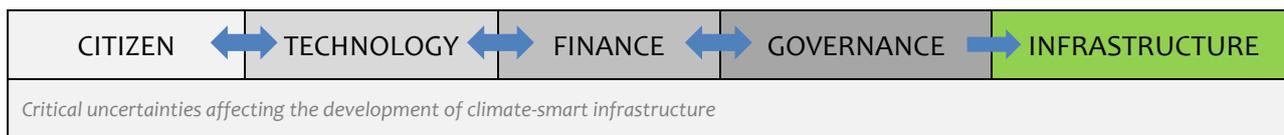
Financing Climate Futures highlighted the need for actions that align the financial system with long-term climate risks and opportunities. Among those actions were new opportunities created by digital finance, particularly with regard to citizen engagement.

This study, which serves as a companion to the main report, looks at how digital finance is already enabling citizens to participate more directly in the infrastructure investment value chain, unlocking new sources of finance for low-emission, resilient infrastructure in both developed and developing societies. Linked with its ability to democratize finance, digital finance can address other aspects of sustainable infrastructure, such as its inclusiveness, social acceptance, accessibility, affordability and efficiency.

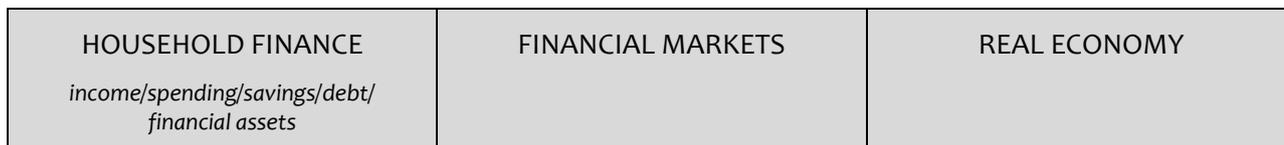
1.2 Methodology

The study involved desk research, interviews and the collection of examples that illustrate innovative applications of digital finance. It covers three central concepts: citizen engagement, digital finance or fintech, and climate-smart infrastructure. Figure 1 highlights key financial system and fintech subsectors through which citizens are engaged in the financing and development of climate-smart infrastructure.

Figure 1: Fintech as Enabler of Citizen Demand for and Supply of Climate-smart Infrastructure



<i>Demand for and supply of climate-smart infrastructure and related services</i>	<i>Delivered via financial technologies, in support of infrastructure development</i>	<i>Cities and towns as networked hubs, facilitating planning, development and accountability</i>
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2 Critical Uncertainties for Climate-smart Infrastructure Development

The *Shifting the Lens*³ briefing by UN Environment on climate-smart infrastructure identified critical uncertainties – rapidly changing events or processes that can have a major impact – relevant to decisions that impact investments in climate-smart infrastructure. Governments need to carry out strategic foresight exercises of critical uncertainties to future-proof investment decisions by monitoring emerging socio-economic and technological changes and continuously adjusting long-term strategies. The following four uncertainties are particularly relevant here:

Citizens: As citizens become more aware of the consequences of climate change, their behaviour may change – including how they use digital technologies and fintech to make a difference. Countries with high fintech adoption rates show real potential to leapfrog in introducing climate-smart infrastructure.

Governance: The resource challenges and opportunities are especially startling in cities, which account for 75% of natural resource consumption, 50% of global waste production, and 60- 80% of GHG emissions.⁴ UN Environment’s International Resource Panel (IRP) has highlighted how different models and styles of governance can have a massive impact on cities by, for example, focusing on Bus Rapid Transit (BRT) systems or by prioritizing compact urban growth and liveable, functionally and socially mixed neighbourhoods.

Technology: The digital revolution is likely to disrupt public utilities, building and construction in coming decades. The McKinsey Global Institute has identified the booming sharing revolution – of transport and real estate, for example – through digital platforms and applications, as one of the disruptive technologies shaping the cities of the future.⁵ The Ellen McArthur Foundation has pointed to savings and GHG reductions that will come with the resource productivity improvements of the sharing economy.⁶

Finance: Impacts of changes to the architecture and functioning of the global financial and monetary system, *i.e.* resulting from the digitalization that impacts business models, citizen engagement, more data-driven risk pricing and related decisions, and the effects of blockchain and cryptocurrencies on trust and cross-border transactions.

3 Types of Citizen Action and Empowerment

To examine the potential for digital finance to enhance citizen action in financing climate-smart infrastructure, we need to understand the different forms of citizen engagement. The common thread is citizen decisions and actions related to finance, enabled through digital technologies. Different types of citizen engagement are set out below in Table 1. Our key interest is the role of the **consumer-citizen** as economic decision maker.

Table 1: Types of Citizen Engagement (e.g. in Financing Climate-smart Infrastructure)

Citizen roles	Function	Fintech aspects, examples
Consumer/buyer-user (demand)	Citizen as buyer and user of certain goods and services	Use of any fintech in the development and operation of climate-smart infrastructure – DLT, Big Data, MLAI, IoT, mobile and internet-based platforms
Collaborator (co-designer, co-problem solver, supply)	Citizen as external expert, provider of ideas working on basis of incentives with public or commercial developer	Co-design and/or open source development of new fintech applications dedicated to climate-smart infrastructure
Learner (capacity, knowledge, awareness)	Citizen as economic decision maker with bounded rationality	Learning via banktech, investech, insurtech applications, for example to enable use of climate-related services offered based on open banking, cloud and GIS
Voter	Citizen as voter in governmental elections, referendums, or in private governance (e.g. AGMs)	Electronic voting, for climate friendly actions by national/regional/local government, by public/private enterprises
Pension holder, investor	Citizen as retail and (indirectly) institutional investor, able to influence investment decision-making	E-voting platforms, AI-based robo-advisor for climate investment purposes, trading in climate-labelled tokens/cryptocurrencies
Interest promoter (campaigner)	Citizen as interest group member, willing to volunteer for campaigns, initiatives	Online and mobile platforms used for mobilization, e.g. crowdfunding for local community climate infrastructure project

4 Climate-smart Infrastructure Types and Value Chain

What is unique about infrastructure, infrastructure finance and the infrastructure value chain? Based on analysis by the G20, OECD and others, the following points can be noted:

- **Fragmented value chain:** Infrastructure and the building and construction industry in particular has historically been a very fragmented industry. Its value chain involves diverse players, including developers, architects, engineers, investors, regulators and eventual asset users (e.g. building occupants) who all have very different incentives.
- **Diverse structure and life cycle:** When regulators and financiers consider risk factors and risk/return dynamics, they need to deal with differences related to financial structure (e.g. dealing with project not corporate level operations) and to a changes in risk level profile depending on different project phases (e.g. greenfield vs brownfield).
- **Lack of transparency and scattered information:** Infrastructure projects and vehicles tend to involve opaque and diverse structures and delivery models (such as public-private partnerships). Financiers therefore face uncertainty due to lack of and scattered information.
- **Complexity associated with scale, timeframe and multi-stakeholder nature:** Infrastructure assets tend to be large scale and long term, involving many public and private stakeholders, all of which bring unique environmental, social and regulatory risks.
- **Concentrated investor community with direct exposure:** The infrastructure investment community is usually investors backing a small numbers of large-scale assets or companies. Large funds may hold assets in various types of infrastructure, while smaller investors may focus on certain subsectors (e.g. utilities in OECD markets). Both have more direct links (and exposure) to their assets, projects where incidents in the field can have immediate implications (including reputational risk) for the investor.

The above show the important role of citizens as a stakeholder group in infrastructure development, as they are the ultimate beneficiary of infrastructure development. It also shows the potential for digital technologies and fintech to make a difference, considering its ability to cut transaction costs, reduce intermediaries, exchange unprecedented amounts of information, and provide analytics and assurance of standards in radically new ways.

Table 2: The Citizen and the Infrastructure Investment Value Chain

Infrastructure project cycle				
Planning, strategy, assessment	Design	Procurement, Construction, Delivery	Operation and Maintenance	Appraisal, Evaluation
Citizens dimension:				
Citizen needs (e.g. basic services), ideas proposed to solve public interest problem (climate-related), infrastructure preferences stated, (sustainability) impacts assessed.	Design of infrastructure and business/operational model that best engage citizens; citizens/community involved in co-design.	Citizens monitoring of budget expenditure and procurement, governance and ongoing developments at construction site (helping to mitigate construction risk)	Citizens' active use of the new infrastructure; involvement in initiatives to support and co-finance upgrades, renovations, maintenance.	Citizens' feedback on infrastructure performance, climate and sustainability impact, ideas for improvement/follow up.
Finance dimension:				
Public financing to initiate (e.g. grants, special loans/bonds), provide guarantees (risk mitigation) for upfront investment, catalyse private investment; consider use of blockchain to reduce intermediation, manage risk and improve transparency.	Securing local/external development finance to cover climate sustainability premiums; depending on size of project, design to include community/crowd financing for smaller scale project or large project subcomponents.	Institutional investors (pensions, insurance, sovereign wealth funds) to provide long-term financing (equity) and insurance; debt providers offer syndicated bank loans; depending on size of project (e.g. 15 years vs 3 months local community installation) citizens indirectly/directly involved, moving tender proposals to include cleantech	Private investors, commercial and individual (households, HNWIs) more suitable to finance operation and maintenance; engage and ongoing reporting (including online, robo) to retail investors on the investment in infrastructure assets.	Loans mature, payback to investors (after e.g. 10 years capital locked in), appraisal by government/collector of ongoing taxes and revenues from infrastructure operations.

Figure 2 presents four main categories of infrastructure of climate-resilient economies. Overall, the focus is on covering the four main categories and paying special attention to interrelations between these in shaping climate resilient economies. Consider for example the interrelation between climate-smart physical infrastructure and societal infrastructure, including economic benefits from environmental and human health perspectives. In outlining environmental and social benefits that result from developing compact, connected cities, the Cities Climate Finance Leadership Alliance (CCFLA)⁷ has cited as example how better road systems in compact cities can reduce congestion, allow for carpooling, and reduce the number of vehicles on the road while also improving air quality, thus driving healthcare savings as citizens breathe less polluted air. Figure 2 also lists the main subsectors of infrastructure, indicating in colour the main focus areas of this study.

Figure 2: Four Interrelated Infrastructure Types and Infrastructure Subsectors of Climate-resilient Economies (Ones in Colour Addressed in this Study)

Transport	Housing	Health	Education	Identity, Security Systems	Compliance systems	Collateral registries, assurance systems	Open Banking
Civic Facilities and Utilities	Societal infrastructure including health and education systems able to address health consequences of climate change, environmental education and financial literacy			Financial infrastructure including collateral (e.g. property) registries, credit reporting and securities (e.g. bond) markets to support finance for climate-smart infrastructure			Information, Transaction and Trading systems
Justice and Corrections							Payment systems
Genes, species	Ecological infrastructure including ability of ecosystems conservation to serve both climate adaptation and mitigation, climate resilience and growth (double dividend)			Physical infrastructure including reliable information technology infrastructure, foundational for fintech applications			Telecoms (ICT)
Habitat, landscapes							Transport
Ecosystems	Land	Forestry	Agriculture	Property	Water	Waste	Energy

The financial infrastructure subsectors will be referenced throughout this study, highlighting main innovation areas for fintech such as trading and payment systems as well as open banking.

5 Citizen Action via Fintech in Climate-smart Infrastructure

Fintech is growing at an astonishing pace, opening up all sorts of new possibilities. Financial infrastructure in the digital age includes developments such as Open Banking and related platforms as encouraged in Europe by the EU Commission, the rise of new payment ecosystems driven in China by the digital giants Ant Financial and Tencent, as well as new electronic identity systems such as the Aadhaar unified payment interface in India.

In Asia, the expansion of ICT infrastructure since the 2000s has been accompanied by rapid increase in connectivity through use of mobile phones. Analysing specific features of fintech development in the ASEAN region, the Singapore-based investment group Tryb⁸ has noted growing connectivity as mobile phone penetration rates have grown rapidly in the last five years, for example in Singapore (80%), Myanmar (93%), Cambodia (173%), Vietnam (131%) and Thailand (133%). While access to ecommerce websites are now commonplace, the same cannot be said about access to formal financial services. Here lies the challenge for financial infrastructure and fintech, directing this trend towards sustainable production and consumption, supported by climate-smart infrastructure.

Considering the different levels at which digital financial technologies support the development of climate-smart infrastructure, this study builds on an analytical framework developed by the UN Environment Inquiry and the SDFA (2018)⁹ to conceptualize the relationship between digital applications and sustainable finance.

The SDFA framework defines four levels of impact, which serve to structure the following analysis. The four levels, with considerations for climate-smart infrastructure, are as follows:

- **Digital finance unlocks innovation for sustainable development:** New business models that especially engage consumer-citizens in innovative ways in support of climate-smart infrastructure development.
- **Digital finance unlocks new sources of finance:** Platforms and schemes that unlock new sources of finance, engaging more citizens in crowdfunding and trading, matching investors and opening new markets related to climate-smart infrastructure.
- **Digital finance offers a wide range of more sustainable choices:** Initiatives and offers that engage and provide more consumer-citizens in/with climate-smart infrastructure, based on more resource-efficient consumption and production options.
- **Digital finance provides improved systems and data for more sustainable financial decision-making:** Greater accessibility of data on climate-smart infrastructure, including project pipelines and impact assessments, for financial decision makers.

This section gives concrete examples of how this new technology is already allowing citizens to support climate-smart infrastructure in each of these four areas.

5.1 Business Model Innovation

Since the 1990s, the Digital Revolution has led to the development of a new range of business models: those that reach out in a decentralized fashion to previously non-connected communities, those that facilitate the sharing of assets, those that facilitate the matching of parties through digital platforms, and those that promote circularity through facilitating reuse and reduction of waste. New digital finance innovations can take such models to new scale in all market contexts.

Relevant factors for new business models include not only industry sector, geography and income levels, but also urban/rural and generation/age group. The IoT Sustainability Guidelines by the WEF (2018) recommend that IoT developers embrace a sustainability awareness culture to respond to new generational demand, mindful that 50% of the world population today is younger than 30 years old.¹⁰

New business models transforming cities

The Commission on the Economy and Climate (2016) noted that urban infrastructure decisions taken over the next five years are likely to determine up to a third of the remaining carbon budget at the global level and will also determine the vulnerability of urban infrastructure to climate impacts.¹¹ This calls for solutions in compact, connected and coordinated urban infrastructure that is low-carbon and resilient. Examples include bicycle infrastructure, affordable mass transport systems such as bus rapid transit (BRT) and energy efficient buildings. On the demand side, sharing and on-demand business models can make a key contribution in areas such as urban transport and buildings.

Box 1: Examples of Transport Infrastructure and Sustainable Mobility

Transmi:¹² The TransMilenio Bus Rapid Transit (BRT) system of Bogotá, Colombia, has led the way in sustainable mobility, cutting the number of car journeys and improving air quality. Today it is supported by the Moovit and Transmi apps, which enable consumer citizens to plan their trips. Linked with Google Maps technology, it calculates approximate time, stops and bus movements. Colombia's biggest retail bank Bancolombia offers a chip card to pay for TransMilenio travels directly from people's accounts.

Transports Public Genevois (TPG):¹³ The mobile app of the Geneva public transport company TPG enables city travellers to plan their journey, track waiting times for incoming vehicles, determine their expected trip length and assess available connections in real-time by tracking the current location of any bus. Users can also purchase their transport tickets with the app, doing their payments for an electronic ticket via SMS.

Mobike and Ofo: Backed by investor Tencent, *Mobike*¹⁴ is a Beijing and Shanghai-based company that allows users to rent bikes through an app. Mobike operates its own bike fleet, with the stated mission to “provide an affordable means of shared transportation for convenient short urban trips, while reducing congestion, and our city's carbon footprint”. *Ofo*¹⁵ is a Beijing-based on-demand bike sharing platform, with Alibaba as a major investor. It is present in 21 countries. Users scan a code from their smartphones to unlock parked bikes and enter their destination and pay via the messaging app. Like Mobike, its sharing platforms use IoT and GPS trackers on their bikes to trace their movements and prevent theft.

Lyft Bikes, Jump and Lime: *Motivate* or now *Lyft Bikes*¹⁶ (since acquired by Lyft in 2018) provides 80% of bike rentals in the US, often partnering with corporate sponsors for advertizing and using the traditional model of set docking points. New York-based *Jump*¹⁷ (acquired by Uber in 2018) was the first dockless bike-sharing scheme to obtain a license from San Francisco. Uber has also joined a fundraising round for *Lime*, one of the first to transplant the dockless bike model into the US and who, with US\$467 million in funding, claims to be the leading dockless bike share provider in the US market. Like Jump, Lime today also offers e-scooters.

The role of local authorities in developing climate-smart infrastructure is critical, considering their role as enablers for taking citizen-fintech initiatives to required scale. The climate and digital strategies of international award-winning “green” cities are summarized in Annex I, including how they engage citizens and promote fintech innovation.

Business models improving rural life

New business models and related fintech innovations also hold great promise in developing climate-smart infrastructure in rural areas. The best known example is that of access to electricity in off-grid areas, driven by a distributed energy business model that challenges the traditional centralized monopolies of power utilities (see Annex II for more examples in the energy sphere).

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-service (PaS) or energy-as-service (EaS) business model allows customers to use products through a lease or pay-for-use arrangement. The model enables payments to be adjusted to the cash profile of low income groups, while smart technology (including IoT) within cleantech products makes it easy to remotely regulate the use of solar devices. Examples include Simpa Networks in India, M-Kopa Solar in Kenya and Quetsol in Guatemala. A growing number of companies are deploying pay-as-you-go (PAYG) solar solutions across Africa, Asia, and Latin America. Some three million PAYG solar systems have been sold globally in the last five years.

Box 2: Improved access to solar energy in Kenya through PAYG

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 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. By 2018 it has connected 600,000 customers to affordable solar power, expected to gain a projected US\$450 million in savings over the coming four years. This investment marked the first time that a commercial loan was secured through mobile money provider M-Pesa.

Business models reshaping agriculture

In the agriculture sector, new business models combined with fintech create innovative opportunities to support development and advance climate resilience. The latest IPCC report (2018) on the implications of a 1.5°C scenario noted possible conflicting demands for pasture and arable land, considering expectations for bioenergy and expanded forests. This underlines the need for sustainable intensification of farming and less resource-intensive diets, both of which have important consequences for business model and value chain design.

Climate-smart infrastructure in agriculture and the application of agtech, combined with fintech-enabled citizen engagement, may shape surprising new farming models. California-based Iron Ox¹⁸ has relied on data related to horticultural knowledge and robotics to design an indoor farm for the future. Today the company uses AI and robots to grow 30 times more produce than traditional farms. While such a system leaves certain elements of traditional farm work obsolete, it creates new agtech jobs that go with scaled-up production for a growing world population.

Indoor and urban farming innovations also include new models of vertical farming. Start-ups such as Plenty¹⁹ report that, relative to conventional agriculture, it can get as much as 350 times the produce out of a given acre of land while using only 1% as much water. Vegetable plants are grown on 20-foot vertical towers, growing out of a substrate made primarily of recycled plastic bottles. Water and nutrients are fed in from the top of the tower and dispersed by gravity, all water is recycled and light is provided from LED lamps. By building on such innovation, fintech can engage urban citizens in indoor farming, paying for growing crops of their preference, tracking progress of their plots remotely and having their harvest delivered at home.

5.2 New Sources of Finance

The most wide-ranging options for applying digital finance in support of climate-smart infrastructure development lie in unlocking new sources of finance – for example through crowdfunding, matchmaking and democratizing investment by opening it up to low-income investors who don't necessarily have bank accounts.

This involves improved engagement of citizens in direct and indirect ways. Direct engagement includes more inclusive financing models that directly engage households in decentralized energy systems or support small enterprises and rural farmers. Indirect engagement is at play in, for example, urban environments, where authorities experiment with new financing vehicles in their attempts to fill the infrastructure investment gap.

Direct engagement of citizens

Improved engagement of citizens in direct ways is linked with the goal of financial inclusion, a keystone of sustainable digital finance. It enables engagement of a larger variety of citizens, including those of lower income status.

Small-scale project financing tends to engage small suppliers and local communities, a situation that is more likely to reflect direct citizen engagement. Important in developing these are business models that create appropriate incentives for developers. Key in less developed economies is the availability of instruments such as micro-financing, portfolio guarantees and aggregation, which connects many small projects and realizes economies-of-scale. Digital finance can facilitate this aggregation role more effectively, providing platforms for involvement of large communities of citizens. Scale is reached also through platforms to pool resources at city government level.

While direct engagement through impact investment has mainly targeted wealthy individuals and institutional investors, digital finance offers new possibilities based on greater accessibility, scale and affordability to target average citizens. For example, in a new project developed by 2° Investing Initiative, a platform is under construction to connect retail investors with banks that offer climate proof and responsible investment funds. Called the “Climate Finance Product Scanner for retail investors and banks” (KliFin-Scanner),²⁰ it involves a profiling questionnaire on non-financial objectives for retail investors. The aim is to enable citizens investing their pensions and household savings to consider non-financial and climate factors, lower transaction costs for banks that offer related retail investment services, and increase transparency.

New digital finance initiatives that engage citizens as retail investors, including online robo-advisors, can unlock new finance and boost liquidity, as well as delivering the real economy impact of filling financing gaps and improving the performance of climate infrastructure projects. It can take various forms, including a savings account product or robo-advisory offered in a developed economy or a retail bond

issued in an emerging economy (see box). The environmental savings account of the Swiss Zürcher Kantonalbank²¹ enables its clients to forego a portion of their interest, which is invested in improving life, environment and air quality in Zurich. The Swiss robo-advisory VIAC²² offers citizens new sustainable investment portfolios, relying on sustainable exchange traded funds (ETFs).

The case of climate-resilient agriculture is also illustrative, and venture capital investors such as Japan's *Softbank* are seeking to bring agtech to global scalability. In the billion dollar market of crop insurance, startups such as *Crop Pro*²³ are innovating to ensure farmers use new technologies. Also in North America, *Bushel*²⁴ is enabling payment processes for retail inputs and in key supply chain steps such as grain storage. In Australia, *CropLogic*²⁵ provides farmers with a scientific crop growth forecasting solution for yield optimization. Similar AI-based services are provided by the American start-up *aWhere* and the Spanish *ec2ec*, providing farmers and investors with data that can be used for insurance and commodity risk hedging purposes.²⁶ Data-driven agricultural insurance and access to finance is also provided across Africa and Asia, by the likes of *Pula*, *Farmcrowdy*,²⁷ *Apollo Agriculture*, and IoT solution supplier *BioMachines*.²⁸ Such data-driven practices can unlock access to finance for farmers.

Direct citizen engagement can also be enhanced by education through fintech platforms. An example is the *Investmate* app of the mobile financial trading platform *Capital.com*.²⁹ The app offers amateur traders courses and articles in trading basics. *Capital.com*'s platform relies on AI to detect the cognitive biases that influence traders, alerting them to facilitate more informed decision-making. It offers markets for trading in cryptocurrencies through contracts for difference (CFDs) as an alternative to trading on cryptocurrency exchanges. The fintech trading platform therefore supports the further development of financial infrastructure through developing new markets and trading systems.

Box 3: Examples of Crowdfunding, Matchmaking and Unlocking Low-income Sources

*Oneplanetcrowd*³⁰ in the Netherlands 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 Europe's leading sustainable crowdfunding platform with more than 25,000 investors. It has raised over EUR20 million since its launch in 2012, providing seed money and growth capital for more than 175 projects.

*Plan A*³¹ is a German climate fundraising and action platform that empowers environmental NGOs by fundraising for them, while engaging donors and audiences through educational content and events. Its campaigns focus on six themes, including forests, energy, waste and sustainable living. Citizens can make donations online through PayPal or by credit card. Its first month campaign mobilized funding to plant over 200,000 trees.

*LittleBigMoney*³² in Colombia is a crowdfunding platform for projects with social and environmental impact. Its platform provides visibility and financing of initiatives, including environmental and clean energy projects, with a personalized experience for all stakeholders. To date, it has facilitated over 4,000 collaborations and mobilized almost 500 million Colombian pesos (US\$170,000).

*Convergence Finance*³³ from Canada has developed an online matchmaking 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. As of May 2018, Convergence had awarded US\$5 million of grants to 15 projects targeting US\$2 billion of investment, with US\$110 million raised (22 times leverage to date with 200+ times expected).

*Motif Investing*³⁴ and *Wahed Invest* are robo-advisors creating low-account minimum, low-fee investment products aligned with investors' sustainability and/or religious values. Building on the experience of Acorns, these companies are specifically targeting younger investors with an emphasis on impact investing. Motif Investing's Impact Portfolios use "positive screening" to align investor's financial goals with their values (for example mitigating climate change) and charge a competitive 0.25% flat annual management fee. Motif offers a B2C digital platform that allows investors to sign up directly with Motif and a B2B white-label that is used by Goldman Sachs and JP Morgan Chase.

Unlocking finance for clean energy

Many examples of unlocking new finance through digital innovation for climate-smart infrastructure are found in the area of distributed clean energy systems. These showcase what has been referred to as "democratizing electricity". In Rwanda, some 600,000 households in remote areas are accessing the Internet, charging mobile phones and lighting their homes for the first time thanks to off-grid solar energy.³⁵ Similar examples of the developmental benefits of bottom-up, cleaner energy system schemes in lower and higher income communities can be found worldwide. The Lumenaza example below demonstrates how software platforms and blockchain technology allow for the development of P2P networks where consumers can buy and sell clean energy. More distributed, cleaner energy examples can be found in Annex II.

Box 4: Local, Distributed Energy Markets – Lumenaza in Germany³⁶

Lumenaza targets micro-producers (e.g. owners of rooftop solar) and aims to connect all of Germany's 1.4 million small power producers. It won the German Federal Ministry of Economic and Technology's IKT innovation award "From the Smart Home to the Smart Grid" in 2013. The company offers utilities a software platform that directly connects small, local producers with consumers in the same region. It also offers small producers a greater sense of impact, having found that they appreciate knowing where the electricity they produce is going.

The company offers full transparency, so users know where their electricity comes from and households with solar panels can sell their surplus power. The company's suppliers are utilities or citizens acting as a utility or energy-cooperative. A typical client may be a municipal utility that offers electricity in a specific region. The platform is called a marketplace or "utility-in-a-box" software.

The case illustrates the possibilities of IT and fintech to enable the establishment of regional electricity markets or P2P energy markets of the future. This is accompanied by growing recognition that the local or regional origin of electricity has a value (certified) and that it can help improve the acceptance for further developing renewables. The case for local production questions the value of building costly long-distance, regional grids. The Lumenaza experience has shown the need for regulators to open the door to time- and location-dependent grid fees. If there are price signals to avoid lack of capacity in the grid, producers and consumers could receive greater financial reward by reacting to what is happening on the network.

Providing access to start-up capital

While innovations such as crowdfunding and P2P platforms provide low-cost ways of reaching millions of users, enabling a new pool of bottom-up investors to participate directly, their creators also need intermediaries to connect them with investors and venture capital (VC) for early stage financing.

Services of this kind are offered by many new financial service providers such as Startupbootcamp,³⁷ which supports early-stage tech founders by providing access to an international network of mentors and investors. Its programmes include support to ten start-ups in Dubai working in the smart city domain. The fintech investment manager Tryb³⁸ from Singapore includes in its portfolio start-ups such as First Circle, a Philippine-based fintech firm that provides supply chain and trade financing to SMEs. It aims to develop a financial technology platform in ASEAN that connects international capital market investors with ASEAN's underserved businesses and consumers. VC investment in agtech has also grown significantly in recent years, and acquisitions of agtech start-ups have been made by large firms.³⁹ Bayer-Monsanto acquired The Climate Corporation for US\$1 billion in 2013, attracted by its services of collecting and analysing field data to help farmers.

Indirect engagement

While the greater part of the infrastructure investment gap will need to be filled by private finance, public finance will continue to play a catalysing role. Public finance is still especially dominant in developing economies, where 60-65% of infrastructure project costs are financed by public resources, compared to only around 40% in developed economies.⁴⁰ Digital technologies can enable faster recycling of public funding to catalyse more private capital into climate-smart infrastructure.

Also noteworthy is the central role of city authorities in developing infrastructure and their sources of finance. Data on local government revenue in OECD countries shows that property taxes, as well as

grants and transfers from central government, are key sources. Social contributions and property income tend to make a limited contribution, while tariffs and fees such as user fees on public transport use, waste collection or parking make significant contributions. It is in the latter areas that digital innovations and fintech will have its most transformative impact.

5.3 More Climate-friendly Consumer Choices and Behaviour

As populations grow, alongside growing wealth and urbanization, we are seeing increasing resource use and waste, which has significant implications for GHG emission levels and climate. This means that every individual has a role to play by making better choices. Alongside these trends of rising incomes and urbanization comes greater connectivity and access to ecommerce websites. By 2025 ecommerce in the ASEAN region is expected to increase by 18 times, travel by four times and hospitality by five times.⁴¹ Fintech provides an opportunity to influence behaviour, through innovations such as gamification tied to ecommerce (see Box 5).

Box 5: Consumer Education and Gamification

*Ant Financial Services:*⁴² In association with UN Environment, Ant Financial Services has initiated 'Ant Forest' in China, the world's first large-scale pilot to green citizens' consumption patterns by using mobile payment platforms, big data and social media.⁴³ The Ant Forest encourages Ant's users to reduce their carbon footprint through providing individualized carbon savings data to smartphones, connecting their virtual identity and status to their earnings of 'green energy' for reduced carbon emissions, and providing carbon offset rewards through a physical tree planting programme. Any activities (for example taking public transport) registered on the Alipay platform are counted and converted into virtual green energy, which grows a tree in the users account. When enough green energy is earned, the tree is converted into a real tree. Over the first sixteen months from August 2016, 280 million people across China joined. The associated behavioural change has resulted in over 2 million tons of cumulative carbon being avoided and over 13 million trees planted.

*Carbon Z:*⁴⁴ Developed by the Ambipar Group and GEDI consulting, this Brazilian app calculates a person's carbon footprint and enables compensation of emissions through reforestation. When carbon emissions are calculated and offset, the user receives a certificate of "Carbon Compensation" that gives the geographical coordinates of the location where trees were planted. The user receives periodic updates of the evolution of the growth of the trees and can discover her/his trees (numbered seedlings) via mobile phone. A similar service is provided by the SOS Mata Atlantica Foundation, a calculator for carbon footprints and reforestation to offset the emissions.⁴⁵

*Ziit:*⁴⁶ The Brazilian app Ziit enables consumers to choose with which energy source they charge their mobile phones. Ziit enables the user to choose different renewable energy sources. The scheme relies on use of Renewable Energy Certificates assuring supplies from solar, wind, water or biomass energy sources. In the process its online services also educate consumers on different types of renewable energy technologies and their significance. It encourages consumer-citizens to become part of a community of supporters of renewable energy in Brazil.

Household insurance (health, vehicles)

*Ping An Insurance Group:*⁴⁷ This Chinese financial conglomerate has actively invested in building a suite of ecosystem partners, services and products to achieve a massive scale of data beyond just financial services. Through a suite of apps in finance, medicine, cars and housing, it is able to take

advantage of data from over 880 million users, 70 million businesses and 300 partners to power its core business. Ping An is able to see the gaps in service and address them to improve diagnosis efficiency and accuracy – dramatically improving the overall quality of its offerings. In the area of vehicle insurance, Ping An’s “Smart Fast Claim” uses image recognition and pricing algorithms to recognize automotive damage, improving claims efficiency by over 40%. Its wide scope of services positions it well to provide clients diverse climate-related insurance products.

Improved access and efficiency in water management and sanitation

Sarvajal in India is a mission-driven social business serving 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, *Sarvajal* is using digital finance tools to sustainably serve poor communities with safe, convenient water. One of the applications of IoT related to water infrastructure is its ability to provide a remote water-monitoring solution that ensures clean water in regions with underserved populations.

Improved waste management infrastructure

“*I Got Garbage*”:⁴⁸ Launched in 2014, this Indian start-up matches garbage producers with waste collectors. Its objective is to take waste-pickers away from landfills, and help them earn a steady and dignified livelihood. Its core principles focus on decentralized and eco-friendly waste management, financial and social inclusion of waste-pickers, and community and volunteer-led transformation. Supporting the goal of smart sustainable cities and a zero-waste-to-landfill model, IGG pursues a collaborative approach that includes technology adoption, infrastructure, delivery model, community engagement and local governance. It helps municipalities with assessment and planning, the identification and training of waste pickers, social media campaigns and stakeholder onboarding onto a tech platform, as well as ongoing monitoring of operations and governance. Today, IGG has a presence in five Indian cities. Through partner transactions on its digital platform, over 10 million Kgs of waste has been recycled and composted.

Cataki:⁴⁹ This non-profit app in Brazil links waste disposers with waste collectors in São Paulo. For the self-employed waste collectors, the waste offers an income based on, for example, plastic and cardboard being worth about R\$0.20/kg and glass at about R\$0.05/kg. *Cataki* seeks to register growing numbers of the estimated 800,000 waste collectors in Brazil. Its online platform also serves to educate consumers about solid waste recycling and encourages them to support in cities across Brazil. On the app, waste collector carts are tracked as purple icons. A future version of the app will allow people to upload photos of their discarded materials, and collectors (*catadores*) will accept or reject them by swiping right or left.

Promoting responsible behaviour

Social Coin:⁵⁰ Social infrastructure, including youth and health initiatives, can be promoted by crowdfunding platforms such as *Social Coin*. Originated in Barcelona (Spain) in 2013, *Social Coin* promotes chains of social actions under the motto “pay it forward”. Corporations, universities, schools and cities have licensed *Social Coin* technology in many countries. It has been recognized by the UN and the EU’s Horizon 2020 Programme. *Social Coin* uses Artificial Intelligence (AI) to collect and analyse data to identify a community’s concerns. This information is presented as a visual dashboard on *Citibeats*. Participants earn social coins by taking part in challenges that solve the identified problems. The AI assigns a number of social coins to each challenge, depending on its

relevance. These values rise and fall as the urgency of the issues evolves over time. In this way social coins create an economy of impact. Social coins can be spent at local businesses. Recent projects include developmental youth work done in Dubai and Costa Rica.

Opower: The behavioural psychology of consumers, and how it can be overcome with fintech innovation, is well illustrated by Opower (established in the US, 2007). Its founders realized that many campaigns by power utilities to convince consumers to save electricity had failed, but that peer comparison made a difference. They developed software to allow consumers to compare their monthly electricity usage with neighbours and people living in similar circumstances. When customers find they are behind their neighbours in efficient use, it changes behaviour. And while a reduction of say 2% in electricity consumption per household may seem little, a 2% reduction in the whole of the US could eliminate the need for 130 power plants. Ten years later, Opower, acquired by Oracle,⁵¹ was covering over 60 million end customers. In October 2018, Oracle said the tool had cumulatively saved 20-terawatt hours (TWh), enough to power San Francisco homes for 10 years.

Boosting 3R in waste management

Major impacts can also be made through improving the reduce/reuse/recycle (3R) approach to waste management. *The Economist* recently gave an overview of how formal waste collection and separation is expanding in the developing world.⁵² There are over 6,000 community waste banks in Indonesia. Residents deposit recyclables in exchange for cash. The availability of door-to-door collection enhances the separation of waste, producing better quality (*i.e.* not mixed) waste. Many cities are also setting up infrastructure with special waste collection points in neighbourhoods. In China, where the WB predicts a 50% rise in solid waste by 2050, the number of incinerators has increased from 57 in 2010 to over 400 today. Boosting its US\$30 billion Swachh Bharat (Clean India) Mission, the Indian Government has recently earmarked US\$9.5 billion for solid waste management. Morocco is investing US\$300 million in new sanitary landfills, which reportedly has already averted US\$440 million in damage to ecological infrastructure.

Linked with the education of residents, many American and European cities today collect different waste materials on alternate days. Supermarkets and other public spaces can introduce reverse-vending machines that accept empty bottles and return money to users. Cities are also adopting pay-as-you-throw (PAYT) schemes.

Supporting such changes in consumer behaviour, fintech applications can take such initiatives to greater economies-of-scale. Since 2017, the free mobile app Cataki in Brazil links those disposing of rubbish with those collecting it in São Paulo. A similar app called “I Got Garbage” is used by Indian raddiwallahs in Bengaluru (see box above for more). While managing waste nationally and globally is influenced by trade restrictions, platforms such as Scrapo and MerQbiz facilitate the exchange of recyclables across borders, supporting circular economy approaches transnationally.

Climate-smart transport

Climate-smart transport initiatives in cities include the introduction of bans and collection of fees via digitally-run toll schemes on major roads. Cities such as London, Milan, Stockholm, Seoul and Singapore have implemented congestion charges. These have reduced travel times, emissions and accidents, while also raising capital for improvement of public transport infrastructure. Consumer-citizen interest and demand will shape the future of urban transport, including the possibility of self-driving vehicles, clean-energy public transport and intermodal transport systems that include trains, buses and bicycles.

Major car manufacturers have taken note of competition by new entrants such as Apple, Uber, Google and Tesla in developing electrical and self-driving vehicles.⁵³ This has prompted them to invest in companies working on self-driving technologies, as well as next-generation manufacturing, energy storage, powertrain and materials technologies. Work related to self-driving vehicles includes investing in mapping and traffic data. Start-ups such as Inrix use real-time data from sensors on millions of GPS-enabled vehicles to build traffic tracking, telematics and mapping products.

The combination of traffic data generated by private and public organizations provide an opportunity for PPPs to define future, climate-smart transport infrastructure that better serves citizen needs. The data is also used to improve the range of climate-friendly choices available to citizens. An example is the mobile phone application TPG Geneva that citizens use to track public transport vehicles, plan their routes and pay for electronic tickets through electronic messaging (see examples box in Section 5.1).

5.4 Improved Systems and Data for Climate-friendly Financial Decision-making

Over the last two decades, the industry of responsible business performance information has grown into an extensive value chain with a whole range of actors in play before information eventually gets to end users. This chain of information is overwhelming for consumer-citizens as potential end-users and pension investors. Fintech can help to engage consumer-citizens in increasingly simple and user-friendly ways, while processing a mass of financial and non-financial data.

Early experimentation in the use of MLAI is resulting in the delivery of online services and robo-advice that, in coming years, will present investment information in increasingly understandable and affordable ways. This also holds for diverse types of material information that institutions and citizens need to make more informed decisions on climate-smart infrastructure.

Informing institutional investors

It can be difficult for institutional investors to find actionable infrastructure projects that clearly meet “climate-smart” criteria. Debates on the infrastructure finance gap often conclude that the capital is available, but the real problem is the lack of a transparent pipeline of bankable infrastructure projects that financiers can refer to. These financiers include private institutional investors, who McKinsey (2016)⁵⁴ has argued could fill half the financing gap in sustainable infrastructure. They are institutional investors such as banks (currently holding US\$40.2 trillion in infrastructure AUM), investment companies (US\$29 trillion in infrastructure AUM), insurance companies and private pensions (US\$26.5 trillion in infrastructure AUM), as well as public pensions, sovereign wealth funds and infrastructure developers.

Box 6: Project Management and Rating Systems to Support Developers and Investors⁵⁵

*SIF-International Infrastructure Support System (SIF-IISS):*⁵⁶ A public project management tool enabling public sector agencies to improve their project preparation activities. It is online and cloud-based, and provides templates for infrastructure projects with the aim of improving the quality, consistency and transparency of project preparation. Its software SOURCE is dedicated to the preparation of infrastructure projects for governments and multilateral organizations. While the system is coordinated by the Sustainable Infrastructure Foundation (SIF) registered in Geneva, its data has been put under UN jurisdiction to ensure data security and provide transnational support.

*CEEQUAL/BREEAM Infrastructure:*⁵⁷ An international evidence-based sustainability assessment, rating and awards scheme for civil engineering, infrastructure, landscaping and works in public spaces. With over 700 project registrations, it has become an internationally recognized sustainability

standard for civil engineering works. BREEAM provides third-party certification of the assessment of the sustainability performance of individual buildings, communities and infrastructure projects.

*GRESB Infrastructure:*⁵⁸ GRESB assesses the sustainability performance of real estate and infrastructure portfolios and assets worldwide. It provides high-quality ESG data and powerful analytical tools to the investment industry, including scorecards, benchmark reports and portfolio analysis. More than 75 institutional investors use GRESB data and analytical tools to engage with investment managers to enhance and protect shareholder value. GRESB Investor Members represent over US\$18 trillion in institutional capital.

*Sustainable Transport Appraisal Rating (STAR):*⁵⁹ Rating system developed by the Asian Development Bank (ADB) to measure a transport sector project's contribution to delivering economic, social and environmental objectives. Its application is linked with a typical development bank (MDB) project cycle. Its environmental rating criteria include GHG emissions and climate resilience, while its social rating criteria are accessibility, employment, affordability, safety, inclusion and social cohesion.⁶⁰

Investors can employ new digital technologies to improve their assessment of such alternatives. While major infrastructure projects are normally expected to deliver predictable cash flows and long-term returns, their start-up involves high upfront investment capital and high transaction costs, including extensive documentation and procedures. Based on use of DLT, new smart contracts may reduce extensive legal-financial documents and agreements. The ability of blockchain to reduce intermediaries and embed extensive documentation and procedures in smart contracts can help to make infrastructure an asset class, including one with climate-smart credentials, that is accessible and transparent to both institutional and retail investors.

In addition, the ability to use blockchain enabled chips in green assets for automated monitoring of green performance – e.g. of quantities of renewable energy produced – and automatic upload of data harvested by the chip onto the blockchain that is managing the investment process will make it easier to monitor the validity of green assets, powered green bond or another green investment instrument. It will make technology the new smart intermediary.

This integrating function of digital finance comes as new actors are delivering intelligence and new types of data to the (climate-smart) infrastructure investment value chain. Today, the development of new financing vehicles includes the establishment of project development services and sustainability rating schemes to address the challenge of a lack of bankable projects. An example comes from the International Finance Corporation's (IFC) InfraVentures⁶¹ which helps with project development and early stage financing. A similar role is played by investment managers and funds that explicitly address climate investment. The Global Commission on the Economy and Climate (GCEC) has argued that there is a need to increase the amount of money going from primary investors into entities such as impact funds that can originate and help develop viable projects.⁶²

The 2^o Investing Initiative, with its Climate Finance Product Scanner for retail investors and banks, is setting out to prove to financial institutions that collecting, screening and managing the relevant financial and on-financial data involved is much more do-able and affordable than assumed. Fintech start-ups such as Eagle Alpha⁶³ offers investment managers exclusive datasets and an analytics platform to assist in the analysis of alternative data across 24 categories, including data from mobile app usage, satellite, reviews and ratings. More examples are presented in the examples box above. Such initiatives

provide a wake-up call for large financial institutions, illustrating what is possible today through employing digital sourcing, analytics and fintech innovation.

The insurance business

In insurance, new innovation possibilities include satellite data, better analytics and more advanced modelling to improve risk identification and integrated risk management, as well as the ability to develop more targeted ways of serving customers. Fintech provides insurance with the possibility to become more focused on preventing risk, in addition to pooling risk as a last resort. Insurance can do this by using internal and external datasets (e.g. real-time sensor data) to predict loss events with greater accuracy and pre-emptively deploy loss-avoidance services. It can prompt users with actionable recommendations based on real-time data, detecting when clients are not covered by their current insurance policies.⁶⁴

Box 7: Examples in the Insurance Sector

*Africa Risk Capacity (ARC) Insurance:*⁶⁵ The ARC insurance is a climate-related, sovereign risk insurance scheme, launched in 2014 under the African Union. With support from its founding partners, KfW (Germany) and DfID (UK), its financial affiliate is the ARC Insurance Company Limited. ARC uses the Africa RiskView tool to estimate crop losses and drought response costs before a season begins and as it progresses, triggering insurance payouts if the rains have been poor. The scheme helps to protect poor citizens from natural disasters as commercial insurance is not a viable option.⁶⁶

*Converge Industries:*⁶⁷ In insurance, manual inspections of properties can be supplemented or replaced by remote assessment with high-resolution cameras. Drone companies focused on insurance include Converge Industries, which has helped ease the work of insurance inspectors. IoT including camera technology can be used to monitor buildings and gauge topography throughout infrastructure developments. New software solutions can enhance project monitoring, site management including risk mitigation measures as well as disaster response operations.

AI-based deep learning is allowing business, including insurers, to use data to teach computers how to learn. By feeding a computer tons of sample data and identifying what that data represents, the computer can learn patterns and begin to make inferences. In the US, the National Energy Research Scientific Computing Center has used NEON, an open-source library from deep learning company Nervana, to train a system to recognize extreme weather events based on visual pattern recognition. Its accuracy in identifying tropical cyclone patterns is of particular interest to disaster management and insurance professionals. Even though the consistent use of quantum hardware by investors is still two to five years away, this new generation of computers can be used to analyse large data sets.

Valuing nature

Digital finance also offers new opportunities for financial institutions in the improved measurement, valuation and management of services provided by ecological infrastructure. It is of special interest to banks involved in commercial project finance and related requirements of the Equator Principles, as well as private and retail banks seeking to offer wealthy and regular individuals special accounts linked with sustainable use of Natural Capital. In its work on the Green Economy⁶⁸ as well as The Economics of Ecosystems and Biodiversity (TEEB)⁶⁹ over the last decade, UN Environment has profiled centrally the role of ecological infrastructure and the natural resource base.

Box 8: Data Mapping and Analytics to Support Finance for Climate-resilient, Ecosystems Infrastructure

*Global Ecosystem Resilience Facility (GERF):*⁷⁰ Developed by consulting group Willis Towers Watson, the GERF was launched in 2018 as global insurance facility to provide innovative finance and risk management solutions to build the resilience of ecosystems and the communities they support. In its first year, Willis Towers Watson is working with Cefas and the University of York in mapping marine ecosystems, assessing risk exposure, and developing risk and value models for coral reefs in Grenada and the wider Caribbean.

*Earth Bank of Codes:*⁷¹ Coordinated by the World Economic Forum and linked with the Earth BioGenome Project, this open global digital platform development has set off to map the DNA sequences of species of the Amazon river basin to codify their rights of usage for industry and researchers in a block chain by 2020. The aim is to counter massive global species loss, encourage conservation and secure new sources of income for indigenous communities.

Research on ecological infrastructure along coastal areas have shown the climate mitigation and adaptation co-benefits of healthy coastal ecosystems that counter the damaging effects of storms, a critical consideration for millions of coastal populations. Case studies from countries including Indonesia (forests and REDD+), Peru (urban water management), Guyana (mangrove restoration) and the Sahel (soil and water conservation management) have illustrated the climate co-benefits that can result from ecological infrastructure conservation projects.⁷² Research by the Convention on Biological Diversity (CBD) and German GIZ (2011) on REDD+ has noted market interest in co-benefits and concluded that well-designed financial compensation mechanisms should aim to achieve multiple benefits simultaneously.⁷³ Other experiences point to the importance of multi-sectoral, multi-level networks in the implementation of co-benefit climate projects. This is a dynamic digital and fintech innovations are well suited to manage.

The water and sanitation infrastructure sector illustrates how utilities in middle- and low-income countries often cannot collect enough money from users to allow full cost recovery, due to poverty rates and longstanding government policies.⁷⁴ In some sub-Saharan African countries as much as 70% of water infrastructure generates no revenue. This signals weaknesses in terms of climate resilience. While 60% of the world's population live in areas of near-permanent water stress, climate change is forecast to make water supply more erratic and unpredictable. Water efficiency is one of the low hanging fruits for resource productivity improvements, addressing persistent inefficiencies in the water sector. The Water Security Rewired⁷⁵ platform of the WEF is supporting the WB Water Global Practice, development agencies, technology innovation and infrastructure companies to harness the potential of digital technologies to overcome issues such as the asymmetry of information and allocative inefficiencies in the water sector.

Application of digital technologies to assess ecosystem services range from new software and analytics to the use of iPads to enable indigenous forest communities to record their observations on developments regarding local species (see box). The Fintech Taskforce of the Banking Environment Initiative (BEI)⁷⁶ in the UK concluded that making this link in applying digital finance requires multi-sector innovation, driven by 'Fintech for Sustainability' to trigger targeted, collaborative innovation between diverse corporations, financial institutions and start-ups. For financial institutions, valuation of relevant ecosystem service impacts and dependencies offer benefits such as actionable information on the viability of projects, more informed engagement and voting in asset management, as well as improved understanding of risk

exposure in determining the pricing of insurance.⁷⁷ Better-informed consumer-citizens, including the digitally literate Millennials, are likely to increasingly ask financial institutions about these topics.

Box 9: Innovative Ways to Collect and Manage Climate and Infrastructure Data

*UAVs (unmanned aerial vehicles):*⁷⁸ New drone technologies offer financial institutions and citizens new ways of monitoring and collecting data. This includes various opportunities to support and further develop climate-smart, resilient infrastructure. DJI Innovations allows teams to conduct research without disturbing natural habitats. The Ocean Alliance has used drones to collect samples from whales. Microsoft is leveraging drone technology to capture and test mosquitoes for infectious disease. This intelligence could be used to protect local residents, and in future could be used to prevent epidemics. For climate scientists, drones offer a solution that can collect data physically follow weather patterns as they develop.

Earth observation (EO) satellites: Data collected via satellite observation are critical for monitoring climate change, including weather forecasting, which enables the development of new insurtech solutions such as weather indexed products to support farmers. The Swiss CelsiusPro⁷⁹ offers global insurance digitalization solutions for insurers with a focus on weather, agricultural and parametric natural catastrophe (NatCat) products. These include weather and yield indexes as well as parametric NatCat insurance schemes, introduced through local insurance companies at affordable rates to farming communities. In France, Crédit Agricole Assurance⁸⁰ and Airbus are pursuing new opportunities for grassland insurance. Improving risk mitigation and adaptation, these insurtech solutions also support more sustainable use of ecosystem services and conservation of ecological infrastructure critical to agriculture.

*UN Climate Chain Coalition:*⁸¹ The new coalition is investigating how distributed ledger technology (DLT) could improve climate change initiatives. This includes creating a transparent system for climate data, emissions data, and how carbon is being traded. Created in 2018 by the UNFCCC, the initiative notes that DLT and blockchain can strengthen monitoring, reporting and verification of the impacts of climate action; improve transparency, traceability and cost-effectiveness of climate action; build trust among climate actors; make incentive mechanisms for climate action accessible to the poorest; and support mobilization of green finance.

6 Risks of Citizen Engagement via Fintech in Climate-smart Infrastructure

Research by the UN Environment Inquiry and the SDFA has pointed to challenges in the introduction of fintech at scale, as well as unintended consequences from its use. These point to opportunity costs as well as risks associated with the use of digital finance to engage citizens in the financing of climate-smart infrastructure. This section considers risks related to the employment of fintech.

6.1 Unintended Consequences, Including Employment, Insurance, Indebtedness and Resources

While digital finance enables greater alignment between financial flows and sustainable development goals, it creates unintended economic, social and environmental consequences. It could create greater inequalities if not appropriately managed. This study has highlighted cases such as automation in agricultural infrastructure, which imply the loss of traditional farming jobs while creating new kinds of farming jobs. This points to the likelihood of transitional arrangements and reskilling as highlighted by the International Labour Organization (ILO) in its work on Green Jobs.⁸²

In the domain of insurance, big data, MLAI and IoT provides insurers with a more granular risk assessment of micro-segments in their markets. As a result, the risk of a person or a population becoming uninsurable is real. It is a risk that also applies to biophysical risks of climate change impacts in cities, energy and water resource provisioning and in agriculture.⁸³ The experience of microfinance has also highlighted unintended consequences, such as over-indebtedness of financially illiterate clients. This, and digital financial inclusion, is being addressed by microfinance actors under the Responsible Finance Forum.⁸⁴ Offering climate-smart fintech services at low cost and massive scale to poor citizens needs to be done carefully so that it does not result in predatory lending and financial crisis.

With respect to environmental consequences, digital technologies have negative side-effects. Hardware production requires natural resources, with which comes ecosystem degradation and damage associated with mining operations. As the number of consumers rises and the lifespan of devices shrinks in response to demand for the latest, the electronics industry was approaching 50 million tons of e-waste annually by 2018.⁸⁵ Energy consumption is also a concern. It has been estimated that global data centres have an annual carbon footprint equal to, if not greater than the airline industry. The energy footprint of Bitcoin is enormous. Issues of excess energy use are beginning to be addressed through new solutions, with data centres and crypto mining companies 'greening' by using hydropower and solar energy. New second- and third-generation cryptocurrencies, relying on algorithms, controlled access and not extensive data mining hold the prospect of radically lower levels of energy use. Still, the demand for and from data centres broadly may triple in the coming decade.⁸⁶

6.2 Cybersecurity, Crime and Corruption in Infrastructure Development

Crime-related risks associated with digital technologies include data security, for example hacking. The complexities and downsides related to vast amounts of consumer data are beginning to surface. The explosion of online platforms raises questions about the use and protection of consumer data. The EU's General Data Protection Regulation (2018), which offers safeguards for the protection of personal data and the integrity of the EU financial system, is having a ripple effect globally.⁸⁷ Worldwide data breaches are causing more calls for greater digital and data protection and education of consumer-citizens.⁸⁸

In the domain of financial infrastructure, new innovations such as cryptocurrencies and initial coin offerings (ICO) still carry the risks of an unclear regulatory environment. The Basel Committee on Banking Supervision (BCBS) has initiated a stock take on the materiality of banks' exposure to crypto-

assets. The Financial Stability Board (FSB) has published a framework, developed with the BIS Committee on Payments and Market Infrastructures, for monitoring the risks to financial stability from crypto-assets. The International Organization of Securities Commissions (IOSCO) is examining regulatory issues around “crypto-asset platforms” such as crypto exchanges. Faced with possible heavy regulation, as well as hacks on exchanges, the price of digital currencies such as Bitcoin, Ethereum, Ripple and Litecoin has seen significant volatility.

Amid growth in banking regulations since the global financial crisis, governmental institutions and central banks have also developed special interest in a new breed of fintech: “regulatory technology” or regtech.⁸⁹ Regtech applications to combat fraud and crime can be applied to the environment and climate field. In 2016, an assessment by UN Environment and Interpol estimated environmental crime at US\$258 billion each year, including money made through illegal logging, poaching, fisheries, mining and the dumping of toxic waste.⁹⁰ They also estimated that up to 90% of the world's electronic waste, worth nearly US\$19 billion, is illegally traded or dumped annually.⁹¹ Improved enforcement, including the use of digital technologies, is an area where professional trading and shipping associations can play a supportive role.

Transparency International⁹² regularly reports that the construction sector suffers from a high corruption perception. In 2011, its Bribe Payers Index ranked public works contracts and construction as the most likely out of 19 industry sectors to find bribes being paid. Anti-bribery legislation in OECD countries has an important part to play in countering bribes paid by construction giants registered in their countries for infrastructure developments abroad. Citizens can support such efforts by working through NGOs to monitor project planning, impact assessment procedures, permitting, procurement and tender processes.⁹³ The Blockchain Council has noted that DLT can help to fight corruption by enabling the release of government funds via blockchain (ensuring funding reaches its destination), the creating of blockchain-based voting systems and making publicly available the address of projects (to trace funds and progress).⁹⁴ The use of fintech to fight corruption in infrastructure development can be employed by public and private organizations alike. Its role can be integrated into national corporate governance codes inspired by the OECD Principles of Good Corporate Governance.⁹⁵

6.3 Education, Standards and Regulation

Societal realities, culture and education in different local contexts may present a real challenge to the take-up of fintech by citizens. In Kenya the launch of the crowdsourcing and monitoring platform Huduma in 2011 was much celebrated by the development community. But a recent assessment shows that of the 3,000 reports submitted via SMS, email and Twitter, none had been resolved. Failures in creating meaningful digital engagement processes may undermine citizens’ willingness to participate and evoke further public scepticism about participatory processes.⁹⁶

In reviewing Education for the SDGs, UNESCO has cautioned that while a digitally automated and connected world helps to secure comfort and quality of life, it should not be allowed to enlarge the gap between the haves and the have-nots.⁹⁷ Governments should take care in avoiding the abuse of new technologies by both citizens and regulators. This includes care in introducing new taxes based on e-commerce (including mobile phone purchases by the poor), in respecting citizen rights when introducing new digital security legislation, and in avoiding abuse of social media.

New and revised standards are important in establishing an easy reference for citizens and their financial management advisors to assess risk and opportunities associated with climate-smart infrastructure.

Standards enable economies of scale and building trust while reducing transaction costs, as users can rely on standardized templates. Additionally, DLT enables decentralized standard-setting with mass participation. Cryptocurrencies provide an alternative enforcement mechanism via trusted 3rd parties that do not rely on conventional, top down legal mechanisms for assurance and operation.

As regards standards and labelling of sustainable and climate-smart infrastructure, investors complain that lack of common definitions lead to slow progress. Consolidation of different frameworks with convergence of approaches and best practices around a standard set of principles can make the market less confusing for investors and companies from diverse sectors with an interest in infrastructure. Multilateral development banks can also support standard setting, notably with respect to riskier greenfield projects as opposed to brownfield projects that commercial investors are more familiar with. While development banks can support the supply of bankable projects, governments and investors need to collaborate in shaping aligned infrastructure development and climate investment plans.

Financial regulators also need to take care in enabling rather than discouraging investment in climate-smart infrastructure. Fintech may offer new solutions in dealing with these dilemmas, based on the capacity of digital to introduce radically different ways of approaching risk (integrated risk management) and time (including discount cash flow analysis). At stake are new regulations (notably Basel III and Solvency II requirements) on investment limits, capital adequacy, reserve requirements, the valuation of assets and liabilities, and limits on foreign investment which discourage investors from making longer-term investments. For banks this includes issues around mismatches in the maturity of assets and liabilities, and for insurance issues around treating long-term investments in infrastructure as having a similar risk profile than long-term corporate debt or investments.⁹⁸

7 Analysis and Recommendations

Efforts to build climate resilient societies face a climate infrastructure investment gap. Citizen engagement can be a driving force for resolving this. If every person on this planet contributed US\$896 annually, we would have the annual investment of US\$6.9 trillion required for low-carbon, climate-resilient infrastructure development up to 2030. While there are many reasons why every person will not be paying that amount annually, the idea highlights the key role of citizens as the ultimate originators, users and beneficiaries of finance and infrastructure.

Citizens can be engaged through various digital finance technologies – as consumers, pension holding investors, co-producers and voters. However, how citizens will respond to increasingly dramatic climatic events is uncertain. A younger generation that is more aware and digitally connected across countries may respond more proactively, particularly in emerging markets, which have some of the highest fintech adoption rates in the world. Mobile phone subscriptions in low-income countries have risen dramatically in the past 20 years (58,47 subscriptions per 100 persons by 2016), creating a soft infrastructure that brings with it access to mobile accounts, the Internet and the ability to become part of long-distance transactions in the wider economy.

As Table 3 shows, countries that have high fintech adoption rates such as China – combined with high levels of emissions and other factors – hold real potential to leapfrog into introducing climate-smart infrastructure.

Table 3: Fintech Adoption Rates by Country, and Related Climate, Technology and Finance Rankings

Country	EY Fintech Adoption Index 2017 – Top 10 countries ranking n=20 ⁹⁹	Country/REIO GHG emissions – Global Top 20 (WRI CAIT Climate Data Explorer) n=191 ¹⁰⁰	Global Innovation Index 2018 (Cornell, Insead, WIPO) ranking n=126 ¹⁰¹	McKinsey Global Connectedness Index 2014, n=131 - total flows of goods, services, finance, people, and data and communication, adjusting for country size	Global Financial Centres Index 2018 (Long Finance, Z/Yen Partners, China Development Institute) top city of ranking n=96 ¹⁰²
China	1 (69%)	1	17	25	3 (Hong Kong)
India	2 (52%)	4	57	30	82 (New Delhi)
UK	3 (42%)	3 (EU 28)	4	5	2 (London)
Brazil	4 (40%)	5	64	43	55 (Sao Paulo)
Australia	5 (37%)	13	20	17	7 (Sydney)
Spain	6 (37%)	3 (EU 28)	28	12	53 (Madrid)
Mexico	7 (36%)	10	56	27	62 (Mexico City)
Germany	8 (35%)	3 (EU 28)	9	1	10 (Frankfurt)
South Africa	9 (35%)	15	58	49	38 (Cape Town)
US	10 (33%)	2	6	3	1 (New York)

What is clear is that societies cannot afford to wait for disasters to happen in order to kick-start climate action at scale. The ability of a younger generation to think more globally and display greater awareness of climate change, combined with the realization among older generations that climatic events are starting to significantly impact their own children within the short-term, signal a transformative moment.

The overview in this study of fintech innovations (see Tables 4 and 5) illustrates the many opportunities fintech provides for seizing this moment.

Table 4: Infrastructure Sectors, Related Fintech and Illustrative Examples

Infrastructure sector	Citizen climate finance star technologies	Case examples
Energy	DLT, internet platforms and mobile applications	Citizens using DLT-based schemes (including tokens) to trade climate credits in city neighbourhoods; using mobile payment systems to access off-grid electricity in rural areas; using fundraising platforms to invest in climate/clean energy bonds.
Transport	Public mobility schemes	Citizens using mobile apps for making use of shared mobility schemes (bicycles, cars); using internet and mobile platforms to track, pay and make use of intermodal public transport.
Telecoms (ICT)	User payment systems, incentive schemes	Citizens using IT hubs provided by their ICT service providers to join open innovation/codesign of climate-related services (including disaster communications); paying for cleaner energy and circularity packages offered by providers of electronic goods.
Waste	Internet and mobile platforms, incentive schemes	Citizens using internet and mobile platforms to pay and join neighbourhood waste collection and recycling schemes; to make use of online markets in 2 nd hand goods (re-use initiatives).
Water	Internet and mobile platforms, incentive schemes	Citizens using internet and mobile platforms for services (e.g. washing) in water-intensive activities; for water efficiency initiatives including pre-paid cards and remote monitoring by water utility of monthly household consumption.
Property (including housing)	GIS, IOT, Big Data, P2P platforms	Citizens making use of insurtech offers employing satellite data and GIS to manage climate-related property risks; using IOT and data systems to centrally manage household electrical devices, heating/cooling and lighting; fundraising platforms for renovations, retrofitting or new buildings.
Health	MLAI, online advice, mobile applications	Citizens using online services to access robotized medical advice on climate-related health issues; doing paid volunteer work in community health (e.g. vaccination) campaigns, coordinated centrally via mobile phones.
Education	Online education, open source, AI-based personalization	Citizens supporting online education on climate change linked with local schools; online education on climate-smart infrastructure investment for investors (including pension funds).

Land	Crowd-engagement/funding platforms, satellite (GIS)	Citizen-voter engagement in land-use planning and financing, e.g. at parliament, pension funds and national development banks; crowd platforms for financing nature-based infrastructure development (adaptation/mitigation) and offsetting projects.
Forestry	Online and mobile platforms, DLT/blockchain	Consumer-citizens using online and mobile platforms to purchase and donate forestry conservation projects; trading climate tokens based on forest development credits.
Agriculture	IOT, robotics, satellite, MLAI-analytics	Citizen-farmers using IOT, satellite and data analytics-based tools to conduct land management practices supported by agri-banks; benefiting from weather index-based insurance schemes (insurtech).

Table 5: Overview of Fintech Application Areas, Case Examples and Sectors Covered in this Study

Citizen roles	Impact levels of digital finance	Technology applications	Examples	Sectors
Citizen as collaborator	Unlocking innovative business models for sustainable development	Internet and mobile, DLT, IoT, MLAI, robotics	Sharing mobility and intermodal transport in cities Leasing, service payment systems in rural off-grid electricity Urban farming models with robotic support	Transport Energy Agriculture
Citizen as finance manager (lender, investor, trader)	Unlocking new sources of finance for climate-smart infrastructure	Matchmaking platforms and DLT, including crowd lending/investing/trading, internet and mobile support	Open platforms to connect citizens with funds, start-ups with venture capital Data support and sponsorships for farmers Project aggregators and resource pooling by small cities Online education in climate finance Health monitoring and finance through mobile	Finance Agriculture Urban authorities Education Health Energy Telecoms

			<p>applications</p> <p>Distributed energy systems, including trading</p> <p>Sovereign and muni-bonds, accessible online and mobile</p>	
Citizen as consumer	Enhancing consumer choice and climate-friendly behaviour	Online and mobile services, including payments and banking infrastructure, gamification, IoT, sharing platforms	<p>Gamification and ecommerce to educate consumers</p> <p>Participatory budgeting by municipalities</p> <p>Online data and social media on city water use/stress</p> <p>Digitally-supported waste collection, management and recycling schemes</p> <p>Urban, intermodal sustainable mobility schemes and traffic data monitoring</p>	<p>Ecommerce</p> <p>Urban authorities</p> <p>Water</p> <p>Waste</p> <p>Transport</p> <p>Forestry</p>
Citizen as pension-holder and investor	Improving systems and data for climate-smart financial decision-making	Analytics and modelling, including big data and MLAI for integrated risk management, robo-advice, IoT for bottom-up data monitoring, DLT smart processing	<p>Online investment advice, profiling and automated management</p> <p>DLT-based smart contracts to simplify and secure infrastructure project development</p> <p>Rating and labelling schemes to guide retail and institutional investors</p> <p>Improved modelling including satellite data for risk management and insurance</p> <p>Ecosystem service-based schemes with mitigation-adaptation co-benefits</p>	<p>Finance</p> <p>Infrastructure as asset class</p> <p>Insurance</p> <p>Ecological (land and natural resource management)</p>

There are, however, barriers, such as:

- Behavioural and data biases that encourage choices based on historic practices rather than forward-looking potential;
- Misaligned incentives and capacity gaps along the investment value chain, from procurement to investment decisions;
- Political economy factors that influence policy and investment priorities, time horizons (particularly the urgency of climate action, with the IPCC giving us 12 years to head off the worst impacts of climate change), as well as citizen and incumbent market interests.

These barriers need to be addressed for fintech to truly fulfil its potential in boosting climate-smart infrastructure. The following analysis and recommendations seek to chart a path that can overcome these barriers in terms of how they apply to the digital citizen.

7.1 Business Model Innovation

KEY FINDING: At the level of business model innovation, the approaches of sharing, circular and service-intensive business models are especially adept at engaging citizens. Yet imperfectly open markets tied to dominant incumbent industries and old conventions restrain the growth of entrepreneurial start-ups in fintech and climate-smart infrastructure development. Market reform, decentralization and improved competition needs to be advanced, benefiting from the ability of digital innovation to reduce transaction costs, diversify competition, and facilitate improved coordination as well as accountable governance.

This study has highlighted certain types of new business models that lend themselves to the engagement of consumer-citizens. These include new ways to collaborate through co-design, sharing and networking; new approaches to goods and services, thinking of products as circular service systems; and new dynamics in defining cost structure and revenues as the internet economy enables low cost business models to become profitable thanks to economies-of-scale.

These new approaches can better service both higher income urban citizens facing sustainable lifestyle choices, and lower income citizens through new digital capabilities applied in bottom-of-the-pyramid (BoP) schemes. Digital finance brings opportunities for creating new markets by securitizing things that were not securitized before, releasing new capital.

A key message is that energy as an asset class and energy infrastructure is about to undergo radical transformation. In particular the power generation industry faces disruption, similar to that experienced by the telecoms industry when the Internet arrived. The message for public authorities and cities is that old monopoly models of power supply and national grids have become outdated and unfit-for-purpose.

While national schemes will still be required for purposes of security and stability, markets need to be opened to allow bottom-up, local-level initiatives (such as micro-grids and distributed energy schemes) to play a complementary role. Governments and regulators could accelerate the opening of energy and utility sectors, allowing liberalized markets to boost bottom-up, decentralized innovations and schemes that connect and link with national schemes.

This requires revisiting national utility operating models, enabling unbundling where relevant and revising business models to engage consumer-citizens in solution co-development amidst radical disruption enabled by the digital revolution. This opening up of energy and electricity markets is not only critical for unlocking innovation and capital, but also for building climate-smart infrastructure and climate-resilient communities.

Beyond the energy sector, this also calls for circular business models that introduce digital finance innovations in sectors such as waste, water, buildings and property infrastructure. Equally, unclear consumer protection and insurance of both the provider and the consumer of the shared asset serves as a barrier to larger-scale adoption of digital asset-sharing platforms. Governments and regulators could consider how to overcome this barrier.

7.2 New Sources of Finance

KEY FINDING: At the level of unlocking new sources of finance, new markets in distributed clean energy systems provide insightful examples of citizen engagement. These include micro-grids in urban neighbourhoods and pay-as-you-go solar models in rural communities. Getting to scale, beyond ad hoc crowd contributions, is hampered by the lack of capacity to initiate new markets and connect entrepreneurs with larger institutions. City authorities could sharpen their role in creating supportive ecosystems, developing integrated strategies that include climate-smart fintech incubators, service intermediaries, co-finance partnerships to deal with upfront costs, as well as participatory planning and budgeting processes.

This study has highlighted the ability of digital to mobilize and aggregate millions of small contributions into impact at scale. This includes the ability to engage citizens not reached by conventional financial infrastructure, for example poor citizens who don't have bank accounts. It also includes the ability of developing communities to leapfrog technologically, for example off-grid communities using the mobile internet, a technological advancement seen today as the one that will have greatest economic impact in the coming decade.

Crowdfunding also holds the potential to provide seed financing for greenfield projects, at earlier stages of project development and proof of concept where conventional investors do not have the risk appetite. Such engagement can involve average citizens that support smaller-scale infrastructure developments (such as micro-grids and local waste management schemes), complementing funding from local or national governmental institutions, or wealthy citizens (High Net Worth Individuals) who are willing to take the risk and complement public development financing.

Action is needed to overcome the barriers to enabling new finance via crowd funding, peer-to-peer lending and other such sources– whether this is on the Internet or facilitated by the blockchain such as via ICOs or types of behavioural or purposeful coins and tokens.

In some markets (e.g. many African countries) crowd funding is completely unregulated and therefore offers no consumer protection, which is a real barrier to growth. In the EU it is more a question of crowd funding regulation being fragmented, making cross-border crowd investments more complicated. A more harmonized regulatory framework across countries can drive up the amounts of capital and options for citizen engagement in infrastructure. One example is to catalyse more capital into sustainable buildings, which offers crowd investments in property, so that people can put their savings to good use and at relatively good return rates

City authorities are key enablers of scale. It is at city level that the most decisive climate infrastructure investments will be made in coming decades, in particular the megacities of tomorrow. Strong growth in green and climate-aligned bonds (US\$895 billion by 2018¹⁰³) include options explored by cities such as Lagos, Mumbai, Amsterdam, Tokyo and Wuhan in China to fund projects on, for example, flood protection and intermodal public transport. In planning and implementing climate-smart development plans, cities need to connect their climate and digital strategies. Our examination of award-winning

“green” cities (see Annex I) has shown that even leaders fail to cross-reference their climate and digital strategies.

City action will also benefit from applying fintech to established practices such as “participatory budgeting”, which development banks have found can serve well to improve accountable financing of education and health infrastructure.¹⁰⁴ At national level, planning and long-term low emission development strategies need to support the critical role of city authorities and municipalities. This includes alignment of national and local fiscal regulations.¹⁰⁵ Local authorities have an array of possibilities for the application of digital finance, including new instruments such as tariffs and fees in developing climate-smart energy, transport, property, water and waste management infrastructure.

City authorities could connect their climate and digital strategies, developing smart cities with enabling and resilient urban ecosystems. In pursuing integration in their development plans, city authorities need to collaborate with local research institutions in developing city fintech hubs or incubators where fintech entrepreneurs are challenged to define climate and related smart infrastructure solutions as part of their value propositions. The development of the urban ecosystem in favour of climate finance innovation needs to promote not only P2P platforms and micro-bonds but also platforms that connect smaller players (including households and start-up SMEs) with larger players such as established firms and institutional investors.

7.3 More Climate-friendly Consumer Choice and Behaviour

KEY FINDING: At the level of consumer choice and behaviour, fintech innovations are helping to offer consumers a wider range of choice in areas such as household insurance, home equipment, water and sanitation, waste management, agrifood supplies and urban mobility. Yet citizens, like investors have behavioural biases and are distracted by the seeming complexity of climate-smart infrastructure as asset class. Overcoming behavioural bias can be achieved through innovations in online learning, peer platforms and gamification, tools that provide education and incentives for change.

Digital finance helps to provide consumer-citizens a wider range of choice for living decent and sustainable lifestyles while benefiting from climate-smart infrastructure. This points to the importance of the citizen as economic-decision-maker – not a perfectly rational decision maker operating in efficient markets, but a subjective human being influenced by convincing stories and displaying certain biased behaviours. Citizens prefer the familiar and simple rather than seemingly complicated alternatives.

This behaviour will change as a younger generation is more connected, globally oriented and aware of the climate problem, and the damaging consequences of climate change starts to manifest in more dramatic ways. But behavioural biases that hold back change need to be overcome by smart design of offerings in online education and apps. The example of Opower (see Section 5.3) demonstrates perfectly how to use behavioural psychology, in particular peer comparison and gamification, to overcome barriers related to behaviour biases.

An important feature of fintech is its ability to not only bring individual consumer-citizens more personalized services, but also its ability to engage the consumer-citizen as co-producer and as co-solution developer in the face of local infrastructure problems. This highlights infrastructure as not just something bought and sold, but as something that citizens are part of. This dynamic is illustrated by examples in this study of urban mobility sharing, waste collection, water risk management and forestry conservation schemes. It also implies engaging citizens in circular economy solutions to the main expense areas of households: food, housing and mobility. These point to the most resource intensive

(and therefore climate impactful) value chains, namely agriculture and food, building and construction, and transport and vehicle manufacturing.

Our study has highlighted examples of how citizens are being engaged in areas such as indoor and urban farming, where farmers apply agtech, water and waste management, as well as urban mobility schemes where online and mobile payment services enable vehicle sharing and improved use of intermodal systems (e.g. bicycles, e-bikes, buses, trains). Citizens can also benefit from improved education and healthcare infrastructure, as online learning (including understanding of and preparedness for climate change), mobile technologies and digital finance are employed to improve education and healthcare services that will be critical for climate mitigation and adaptation. The link with finance and fintech in the application of digital technologies in education and healthcare infrastructure, including micro-finance via insurtech, is under-explored.

National, regional and local authorities could convene education and healthcare players in initiatives to build on experience in digital education and digital healthcare innovation, but with the brief to specifically make the link with finance and fintech innovation in promoting climate-friendly lifestyles and climate-smart infrastructure in the urban or rural environment. In addition, they could also convene agriculture, land management and property developers to develop action plans for climate-resilient infrastructure (including ecological infrastructure), with the brief to specifically consider more compact, resource productive urban development, including urban farming (employing agtech), and how digital and fintech innovation can be employed to support the implementation of such plans.

7.4 Improved Systems and Data for Climate-friendly Financial Decision-making

KEY FINDING: At the level of improved systems and data, fintech enables citizens and investors to access more relevant data on climate-smart infrastructure. Yet the fragmented infrastructure industries suffer from barriers in the form of outdated standards and complex organization, which result in high resource and carbon intensity, as well as proneness to bribery and corruption. Regulatory and professional bodies need to address this through the development of improved standards and relevant labels that signpost recognized climate standards, as well as use of digital financial technologies for improved transparency and accountability.

Improved information systems and data for decision-making lay the groundwork for a better understanding of climate-smart infrastructure as a resilient asset class, including the ability to provide related services to citizens as retail investors and pension holders in an accessible and affordable manner. It is evident that pension fund secretariats and their delegated investment managers also need improved education in responsible and climate-smart investment. As market interest moves beyond listed equities and fixed income to other asset classes, ESG analytics on alternative assets such as real estate and infrastructure is improving. Investor engagement can also be supported by data providers, rating agencies, consultants and professional associations who monitor and assess climate-related metrics.

Digital innovation and fintech enables the processing of structured and unstructured data in transformative ways, building on data collected in new ways through, for example, use of satellite technology and scanning of big data across siloed sectors and organizations. While automation may remove jobs in basic financial analysis, new jobs in more complex climate and sustainability analysis will be created to complement software analysis. Through screening, data processing and profiling, fintech will also support the introduction of new standards and labels that provide citizens as retail investors,

pension holders and taxpayers greater assurance of where their money goes and its impact on climate-smart infrastructure development.

Public and private decision makers can advance education and standards for mainstreaming of integrated assessments, risk management and financial analysis applied to climate-critical infrastructure, based on a new understanding of fiduciary duty and relevant time frames. Regulatory and standards bodies need to establish transnational public-private partner initiatives to advance the accessibility and reliability of automated, climate-smart financial advice as well as climate-labelling of infrastructure investment products, the assurance of which includes a guarantee of life cycle monitoring. This includes the introduction of standard ratings and climate labelling that provides for both “smart” and “unsustainable” determination of infrastructure assets for financing purposes.

ANNEX I: Award-winning Green Cities, Their Climate/Digital Strategies and Fintech Ecosystems

CITY: (i) forms of citizen engagement offered by city council, (ii) city climate strategy, (iii) city digital strategy, (iv) performance data	Climate and Digital Strategies cross-referenced: YES/NO/WEAK	City international fintech hub ranking	Local climate, sustainability fintech champions
AMSTERDAM	Climate and Digital Strategies Crossref	Fintech hub ranking	Local fintech champions
<p>Amsterdam’s coalition agreement “A new spring and a new voice”¹⁰⁶ for the 2018-2022 period has “healthy and sustainable city” and “participatory and digital” as two of six ambitions. (i) Measures to advance the “Participatory and digital”¹⁰⁷ agenda include the participation of citizens in making designs and reaching decisions, for example in the creation of gas-free neighbourhoods and the Climate-Neutral Roadmap. Therefore, seven co-creation centres are set up in city districts and best practices are exchanged via the Fearless Cities network. (ii) Amsterdam is developing a “Roadmap for a Climate-Neutral Amsterdam 2050”. Focus is on energy, green spaces, smart mobility and the circular economy.¹⁰⁸ (iii) The digital strategy is not only advancing more participation. Amsterdam city also wants to promote the sharing of data¹⁰⁹ and establishes seven co-creation centres in city districts to support this. (iv) Amsterdam has created a fund for the “energy transition/free from natural gas fund” with €37.5 million per year.¹¹⁰ It consumes very little water, at 146 litres per person per day, decisively less than comparable cities.¹¹¹ Due to its elevation below sea level, Amsterdam is vulnerable to flooding. The initiative “Rainproof.nl” connects stakeholders to improve flood resilience, e.g. by reducing sealed areas.¹¹²</p>	WEAK (digital innovation is used to include citizens in decision-making, to foster collaboration and to inform about projects)	#5 of top 30 - 2017 IFZ Fintech Survey, Institute for Financial Services, Lucerne University 3d highest fintech invested city in EU for 2005-2015, following Stockholm and London	Startup: Photanol ¹¹³ Innovation Hub/Incubator: Cityzen Smartcity ¹¹⁴ ACE incubator ¹¹⁵ R&D: University of Amsterdam ¹¹⁶
CAPE TOWN	Climate and Digital Strategies Crossref	Fintech hub ranking	Local fintech champions
<p>Cape Town city council¹¹⁷ offers e-services through various online portals, including that for land use and building applications, e-billing, health and waste recycling. For (i) public participation, its online services offer issues for public comment, comment on land use applications, opinions surveys and an open innovation platform. Since 2006 (ii) the city has an energy and climate change strategy, also linked with adaptation and biodiversity plans. It runs a climate change coalition of various local stakeholder groups. It has a new Climate Change Policy which supports the city's Integrated Development Plan, Economic Growth Strategy and Social Development Strategy. While a city digital strategy is still under development, the climate policy does refer to alignment with the Economic Growth Strategy, including its pillar “Providing the right basic service, transport and ICT infrastructure”. The city's Electricity Savings Campaign includes a social marketing campaign and an Accredited Solar Water Heater Programme aimed at residents.¹¹⁸ (iii) Its Smart City Strategy includes projects such as a broadband digital inclusion strategy.¹¹⁹ In 2018 the city issued a call for ideas for use of digital technologies to improve performance. It has made significant investments in fibre optic infrastructure, a CCTV camera network and Wi-Fi connectivity (including Wi-Fi hotspots). During (iv) drought over 2015-2018, the city faced the prospect of being the first world city to run out of water. Online support in a citizens campaign included making available water savings toolkits (e.g. posters). The council provides an online water map, that among others shows water use per household and encourages residents to submit their monthly water meter readings for online account payment services. The city Open Data Portal includes data on monthly water consumption by suburb and levels of the six major cities dams.</p>	WEAK (climate policy refers to alignment with Economic Growth Strategy, including basic services, transport and ICT infrastructure)	#27 of top 30 - 2017 IFZ Fintech Survey, Institute for Financial Services, Lucerne University Weak aggregate index score (conducive environment for fintech growth) among 44 global fintech centres, alongside Johannesburg and Mexico City – Global Fintech Hubs Report Deloitte 2017	Startup: The Sun Exchange ¹²⁰ Innovation Hub: Startupbootcamp Cape Town ¹²¹ R&D: Explore Data Science Academy (including AI and water) ¹²²

SAO PAULO, Brazil	Climate and Digital Strategies Crossref	Fintech hub ranking	Local fintech champions
<p>Sao Paulo is a member of the C40 Climate Leadership Group. Like various Brazilian cities, Sao Paulo has developed green policies. (i) Citizens are invited to engage with the Office for the Environment through councils, conferences, public hearings, and consultations and social dialogue.¹²³ (ii) According to the Green City Index, São Paulo has one of the most robust climate change action plans in the Latin American region. Its Climate Committee¹²⁴ coordinates Sao Paulo's climate action via its eight working groups,¹²⁵ e.g. on transportation, resilience, biodiversity and water. Sao Paulo has a high risk of water stress and scarcity due to climate change. It has built thermoelectric powerplants that run on biogas of its landfills and produce around 7% of the city's energy demands. Its public transport system employs many electric buses running on priority bus lanes.¹²⁶ (iii) Sao Paulo's digital strategy focuses on digitizing its internal processes related to citizen services. In addition, public Wi-Fi and traffic signalling are being expanded. CCTV is applied to address the city's high crime rate.¹²⁷ (iv) Brazil has more fintech start-ups than any other country in Latin America, with venture capital investment reaching US\$161 million in 2016. Sao Paulo is its centre, with entrepreneurs becoming more attractive in an economy struggling with high unemployment.¹²⁸</p>	NO	<p>#28 of top 30 - 2017 IFZ Fintech Survey, Institute for Financial Services, Lucerne University</p> <p>Weak aggregate index score (conducive environment for fintech growth) among 44 global fintech centres, alongside Johannesburg and Jakarta – Global Fintech Hubs Report Deloitte 2017</p>	<p>Startup: Nubank¹²⁹</p> <p>Innovation Hub/Incubator: Startup.farm¹³⁰</p> <p>R&D: IPT – Institute for Technological Research¹³¹</p>
SEOUL	Climate and Digital Strategies Crossref	Fintech hub ranking	Local fintech champions
<p>Seoul follows sophisticated planning processes that make use of its advanced data base and e-government platform. (i) Seoul city government installed the “Green Seoul Citizen Committee” which is chaired by the mayor and has 100 members from non-governmental organizations and businesses. It engages various stakeholders in environmental decision-making. (ii) Seoul plans to implement a real-world pilot of a “Smart Energy City” in its Magok neighbourhood. It is expected to achieve 30 percent of power self-sufficiency rate by 2022, reduce 190 tons of fine dust and 180,000 tons of GHG emissions per year. Seoul also pioneers water harvesting in ten neighbourhoods where community involvement is sufficient.¹³² (iii) Seoul uses many advanced smart city technologies already today, with its citizens used to trying out fully digital services early on.¹³³ E-Government services in South Korea have received international recognition with a platform that ensure compatibility of various services.¹³⁴ (iv) Seoul stands out with the densest public transport network in the Asian Green City Index: 6.6 km per km² versus the average of 1.7 km per km².</p>	YES (using digital platform to develop strategies and pushing smart city approach to reduce environmental impact)	Among top 10 centres of Asia Pacific in Green Finance Index (2018), but not rated on fintech	<p>Startup: Toss¹³⁵</p> <p>Innovation Hub/Incubator: Orange Farm¹³⁶</p> <p>R&D: Seoul National University¹³⁷</p>
SINGAPORE	Climate and Digital Strategies Crossref	Fintech hub ranking	Local fintech champions
<p>Singapore has a long history of regulating and managing environmental themes due to its challenging water supply and its high population density. (i) Public consultations and hackathons are two platforms the government has used to gather views and suggestions from individuals who are passionate about climate change and sustainability issues, and who want to contribute ideas or solutions to these challenges. A public consultation exercise conducted from January - May 2015 resulted in over 1,000 comments and suggestions on Singapore's efforts to reduce carbon emissions in the post-2020 period. In 2013, EMA and Singapore Power co-sponsored an Energy Efficiency for Everyone (E3) Hackathon with 80 participants. Many efforts focus on research partnerships and pilots in public spaces. (ii) The Sustainable Singapore Blueprint¹³⁸ focuses on waste, public transportation, drainage, green spaces, and community stewardship. In addition, the “Climate Action Plan”¹³⁹ has ambitious CO2-reduction targets, aiming to reduce emissions by 36% between 2005 and 2030. Smart devices and home energy management systems are piloted to reduce building energy consumption (including air conditioning). Mobility pricing is in place for public and private transportation. (iii) Singapore's Committee on the</p>	NO (same strategy document, but no connection)	<p>#1 of top 30 - 2017 IFZ Fintech Survey, Institute for Financial Services, Lucerne University</p> <p>#4 following London, California, and New York in EY (2016) Study for UK Government</p>	<p>Startup: Electrify.SG¹⁴¹</p> <p>Innovation Hub/Incubator: Plug and Play Singapore¹⁴²</p> <p>R&D: Agency For Science, Technology and Research (A*Star)¹⁴³</p> <p>Center for Liveable Cities¹⁴⁴</p>

<p>Future Economy has drafted seven strategies, “Building strong digital capabilities”¹⁴⁰ being one of them. Although the committee also recommends advancing climate change mitigation and resilience, there is no connection between the digital skills and the sustainability efforts. Since 2009, after a series of smart card innovations, citizens can use e-Symphony, an IBM-designed payment card for paying road tolls, bus travel, taxis, metro and shopping. The resulting data is analysed and used to reduce traffic congestion. The city is also developing a software to facilitate planning of a sustainable city infrastructure. (iv) Singapore is the top performer in the Asian Green City Index and shows consistently strong results across all individual categories.</p>			
SYDNEY	Climate and Digital Strategies Crossref	Fintech hub ranking	Local fintech champions
<p>Sydney’s sustainability performance excels in land use, transport and water, while being behind on improving the energy efficiency of its buildings.¹⁴⁵ It is a member of the Cities Climate Leadership Group. (i) Citizen engagement in Sydney is done via community consultations, community groups and volunteering. It has various gardening-related engagements, e.g. community gardens, footpath gardens along the street, bushcare, and a city farm.¹⁴⁶ (ii) Sydney developed an “Environmental Action strategy and action plan”¹⁴⁷ and a specific strategy for “Adapting to Climate Change”.¹⁴⁸ The former is an encompassing strategy encompassing buildings, carbon reductions, water and waste management, climate resilience, parks, and mobility. (iii) Sydney’s digital strategy¹⁴⁹ focuses on six priorities, most of them aiming to improve social life, citizen services, skills and innovation in general. It is also highly attractive for fintech start-ups, e.g. by establishing a regulatory sandbox that allows eligible fintech businesses to test certain services for up to 12 months without an Australian Financial Services Licence (AFSL) or Australian Credit Licence.¹⁵⁰ (iv) Sydney is building a new city centre called Green Square on 278 hectares. US\$9 billion will be invested to create living space for 61000 people, an area that will include the application of many cleantech innovations.</p>	<p>WEAK (digital strategy mentions the need to research smart infrastructure to fight climate change once, Climate and Environmental strategy mention only application of smart devices)</p>	<p>#13 of top 30 - 2017 IFZ Fintech Survey, Institute for Financial Services, Lucerne University #6 following London, California, New York, Singapore and Frankfurt in EY (2016) Study for UK Government</p>	<p>Startup: Finch¹⁵¹ Innovation Hub/Incubator: Fintech Australia¹⁵² R&D: National Climate Change Adaption Research Facility¹⁵³</p>
VANCOUVER	Climate and Digital Strategies Crossref	Fintech hub ranking	Local fintech champions
<p>Vancouver ranks second overall in the US and Canada Green City Index. It is first for CO₂ and air quality and among the top 10 cities for all other Index categories. (i) Citizens are encouraged to participate in Vancouver’s government and community affairs. The city council runs public consultations, surveys, volunteer committees or boards as well as active dialogue on social media. Citizens can apply to speak at a City Council meeting.¹⁵⁴ (ii) Vancouver developed a climate change adaptation strategy based on the Local Governments for Sustainability (ICLEI) planning framework. It focuses on managing rising sea water and resulting risk of flooding. Vancouver’s “Greenest City Action Plan” pursues 10 goals in the areas of “zero carbon”, “zero waste”, and “healthy ecosystems”. Its commitment to reducing GHG emissions is substantial, resulting in very low CO₂ emissions per capita. Vancouver plans to reduce community-based greenhouse gas emissions by 33% between 2007 and 2020. However, performance is lagging, with a 7% reduction up to 2017. (iii) Vancouver’s digital strategy¹⁵⁵ focuses on the organizational challenges and services of the municipality. The city hosts competitions on smart city innovations and employs them in various field, e.g. traffic signalling or bike sharing.¹⁵⁶ An incubation program focuses on green and digital companies who get access to the city’s resources in order to accelerate their path to the global marketplace.¹⁵⁷ (iv) Vancouver has the longest public transport network in the US and Canada Index. Its 2050 targets are 100% renewable energy and 80% CO₂ reduction from a 2007 baseline.</p>	<p>NO</p>	<p>Tracing Toronto, home of most Canadian fintech start-ups that has good aggregate index score (conductive environment for fintech growth) among 44 global fintech centres, alongside Frankfurt and Stockholm – Global Fintech Hubs Report Deloitte 2017</p>	<p>Startup: Awesene¹⁵⁸ Innovation Hub/Incubator: Innovate BC¹⁵⁹ R&D: University of British Columbia¹⁶⁰</p>

ZURICH	Climate and Digital Strategies Crossref	Fintech hub ranking	Local fintech champions
<p>With a 76% majority in a 2008 referendum, the people of Zurich voted yes to become a 2000-Watt-society by 2050. This corresponds to 1t of annual CO₂e emissions per person.¹⁶¹ (i) Various engagement channels are offered by the city council, e.g. conferences, stakeholder consultations, social media and a variety of apps, e.g. to check air quality and to receive information on waste management.¹⁶² (ii) The city's climate policies and activities are developed under the umbrella of the 2000-Watt-society. An analysis of inner-city temperature anomalies and levers has been carried out to identify next steps.¹⁶³ Its utility companies ewz and Energie 360 are mandated to reduce GHG emissions, with ewz supplying 100% renewable electricity. For most other climate related measures, the city of Zurich refers to the canton and the national government. (iii) Zurich's IT strategy focuses on e-government services, data privacy and internal efficiency measures.¹⁶⁴ Incentives for start-ups by the city are restricted to free information¹⁶⁵ and a free 2-hour consultation.¹⁶⁶ (iv) Currently citizens are responsible for a constant use of 4200 Watt, more than double of the 2050 target. In addition to the energy reduction, energy has to come from 75% renewable sources in order to reach the CO₂ targets. It is unclear how far measures will have to go. Experts agree that less mobility and smaller apartments are necessary to reach the 2000-Watt target.</p>	NO	<p>#2 of top 30 - 2017 IFZ Fintech Survey, Institute for Financial Services, Lucerne University</p> <p>Good aggregate index score (conducive environment for fintech growth) among 44 global fintech centres, alongside Hong Kong, Sydney – Global Fintech Hubs Report Deloitte 2017</p>	<p>Startup: Carbon Delta¹⁶⁷</p> <p>Innovation Hub/Incubator: Impact Hub Zurich¹⁶⁸</p> <p>Climate KIC Switzerland¹⁶⁹ with the Climathon Events¹⁷⁰</p> <p>R&D: ETH Zurich¹⁷¹</p>

ANNEX II: Examples of Distributed Energy Markets, Including P2P Trading, Carbon Product Trading, Microgrids and Virtual Plants

*Jouliette*¹⁷² is a Dutch energy transaction platform that runs on blockchain and covers the community's private smart grid. Community members can make P2P transactions and exchange renewable energy on the community smart-grid. The application incorporates machine-learning forecasting systems and features a real-time power-flow map. Jouliette can integrate intra-community activities such as car sharing and local time banking. System developer Spectral delivers the blockchain software, as well as hardware for metering and data collection.

*GREENEUM*¹⁷³ offers a blockchain-based, P2P green smart investment platform using smart contracts and targeted Artificial Intelligence (AI) with a consensus algorithm. This Israel-based start-up enables energy market participants to connect and optimize their performance. Producers are rewarded with green certificates and GREENEUM tokens and can get slightly higher energy prices as producers receive a transaction fee on every transaction on the grid. Consumers profit from lower energy prices and can get carbon credits through the GREENEUM platform. Utilities can get insight into more energy consumption predictions and operate plans more efficiently. They get a distribution and service fee from GREENEUM, and GREENEUM charges a validation fee on every transaction on the platform.

*SolarCoin*¹⁷⁴ is a rewards programme for solar electricity generation. It is an open community project run by volunteers working together as the SolarCoin Foundation, a US Public Benefit Corporation registered in Delaware and with 24 affiliates from different parts of the world. Solar PV owners receive 1 SolarCoin by generating one MWh of electricity. The SolarCoins can be redeemed for goods and services from participating merchants or exchanged for fiat or cryptocurrencies on online exchanges. This revenue stream, on top of regular feed-in-tariffs or net metering regimes, reduces the payback time for solar installation. SolarCoins run on a public blockchain similar to Bitcoin, with the distinction that the transactions are verified by proof of solar energy generation and proof-of-stake.

*LO3 Energy*¹⁷⁵ is a US-based company building decentralized energy trading platforms. The company partnered with ConsenSys and local energy providers to implement P2P energy trading platforms Brooklyn microgrid¹⁷⁶ in New York and Allgäu Microgrid¹⁷⁷ in Germany. Energy consumers can choose where to buy renewable energy: the local microgrid or the regional power provider. Also, consumers can decide how much they want to spend on the energy source per day. In this way they can express their personal preferences towards maximizing return or benefitting the community.

*WePower*¹⁷⁸ is a renewable energy project financing platform. Headquartered in Lithuania, it also has offices in Estonia, Spain and Australia. Investors of any size can participate in the growth and development of renewable energy projects financed through the WePower platform. Due to a simplified investment process with lower administrative costs, investors and project developers can expect a higher return on equity. Energy consumers benefit from lower energy prices than from conventional markets. Consumers are guaranteed to buy green energy and get more transparency. Energy producers sell their excess power on WePower's blockchain-based platform. It tokenizes the generated energy and makes it tradeable on the platform (1 token = 1 kWh). WePower is partnering with a transmission operator and legally acts as an independent energy supplier. WePower is buying and selling energy from the wholesale market. Energy producers who want to finance a new project through the platform, sell part of the future energy on the platform in form of smart contracts for each token to the investors. The energy has to be delivered at a specific time. The smart contracts serve as power purchase agreements.

*PowerLedger*¹⁷⁹ provides a P2P marketplace for renewable energy. The software solutions offered by this Australian start-up includes P2P trading, microgrid trading, carbon product trading, electric vehicle settlement and virtual power plants. On the one hand, residential and commercial businesses can benefit from installing roof-top PV and selling it to local consumers. Not dependent on a retail price, they can decide to whom they sell their surplus energy and at what price. The buying consumers profit from clean, low-cost energy directly from their neighbours. Two tokens are utilized by Power Ledger: POWR and Sparkz. POWR can be purchased on cryptocurrency exchanges. They are required to participate on the platform. Further, POWR tokens serve as a reward for prosumers generating (favouring RES) and consumers purchasing electricity on the platform. Sparkz are purchased via fiat currencies. One Sparkz equals one unit of electricity and serves as payment for electricity. POWR can be exchanged for Sparkz, but can also be used directly in P2P trading. Accordingly, Power Ledger makes use of a hybrid public Ethereum and consortium blockchain. The first one is used for the POWR token processes, while on the latter is the core layer and incorporates the processes necessary for P2P trading such as meter readings, Sparkz management and payments. Power Ledger receives two revenue streams. First, it charges a fee on all P2P transactions. Second, Power Ledger licenses its P2P trading solution to retailers.

*The Sun Exchange*¹⁸⁰ in South Africa is a blockchain based solar panel micro-leasing marketplace. Investors can purchase solar cells as part of a crowd-sale through the exchange. After implementation of the solar PV, investors earn a real-time rental income per kWh consumed. The platform serves to make solar energy system benefits more accessible to individual citizens. A participant's solar cells go to power the business or community of his/her choice. The participant can pay by local or international bank transfer, or using bitcoin. Once all the solar cells have been purchased, the appointed solar installation company gets the go ahead and begin preparations for installation. When eventually purchased solar cells are operating, the Sun Exchange collects and pays the participant his/her monthly lease rental payments into a convenient wallet. Earnings are calculated on the amount of electricity his/her solar cells have produced. Community roof owners usually are able to reduce their electricity costs. The Sun Exchange acts as a service provider to validate the solar projects commercially and technically, markets them as investment opportunities and arranges the lease agreement. The Sun Exchange receives a fee of 5-25% of every successfully funded solar project and an annuity of 2.5% for the loan period of every project. In its initial two years of existence, the company has attracted participants from over 50 countries.

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