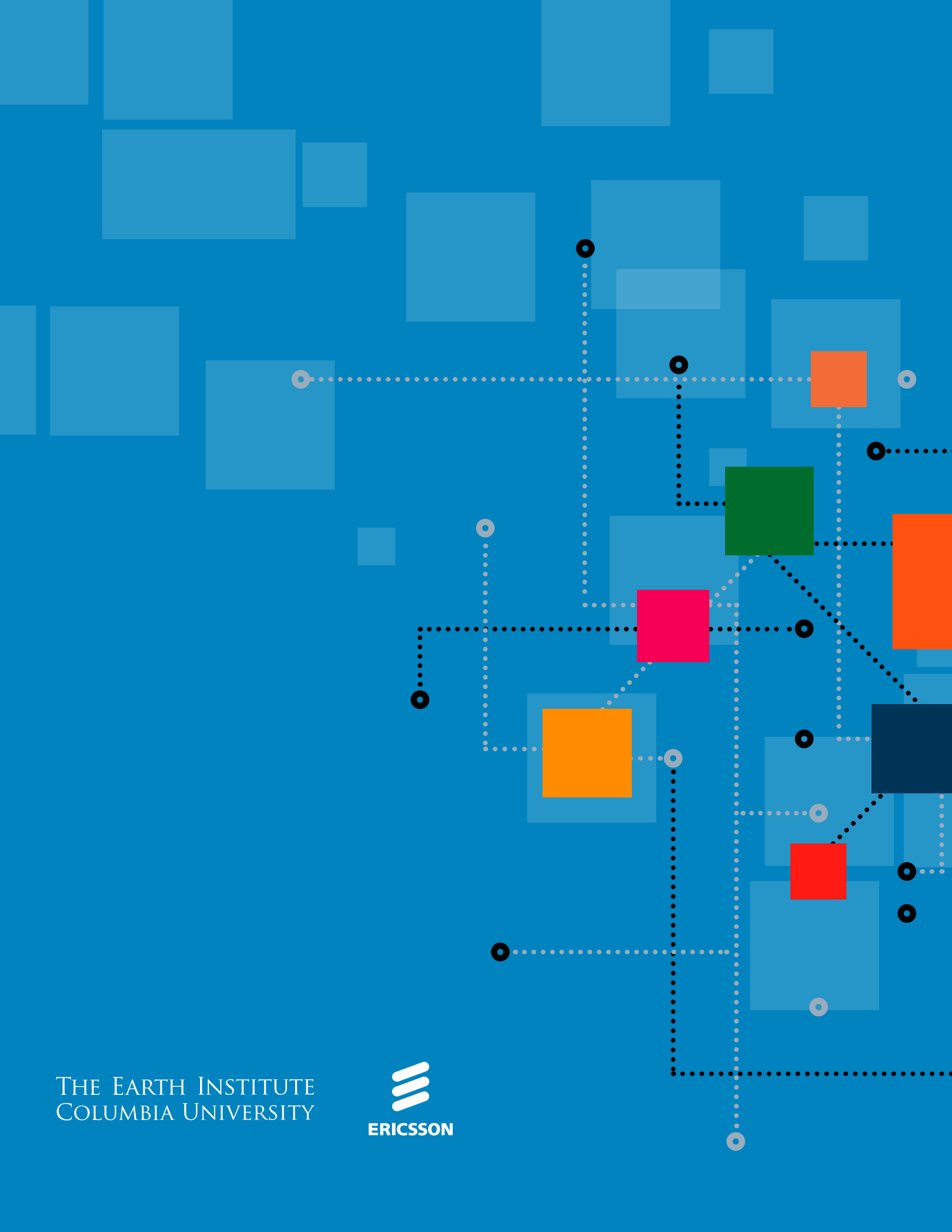

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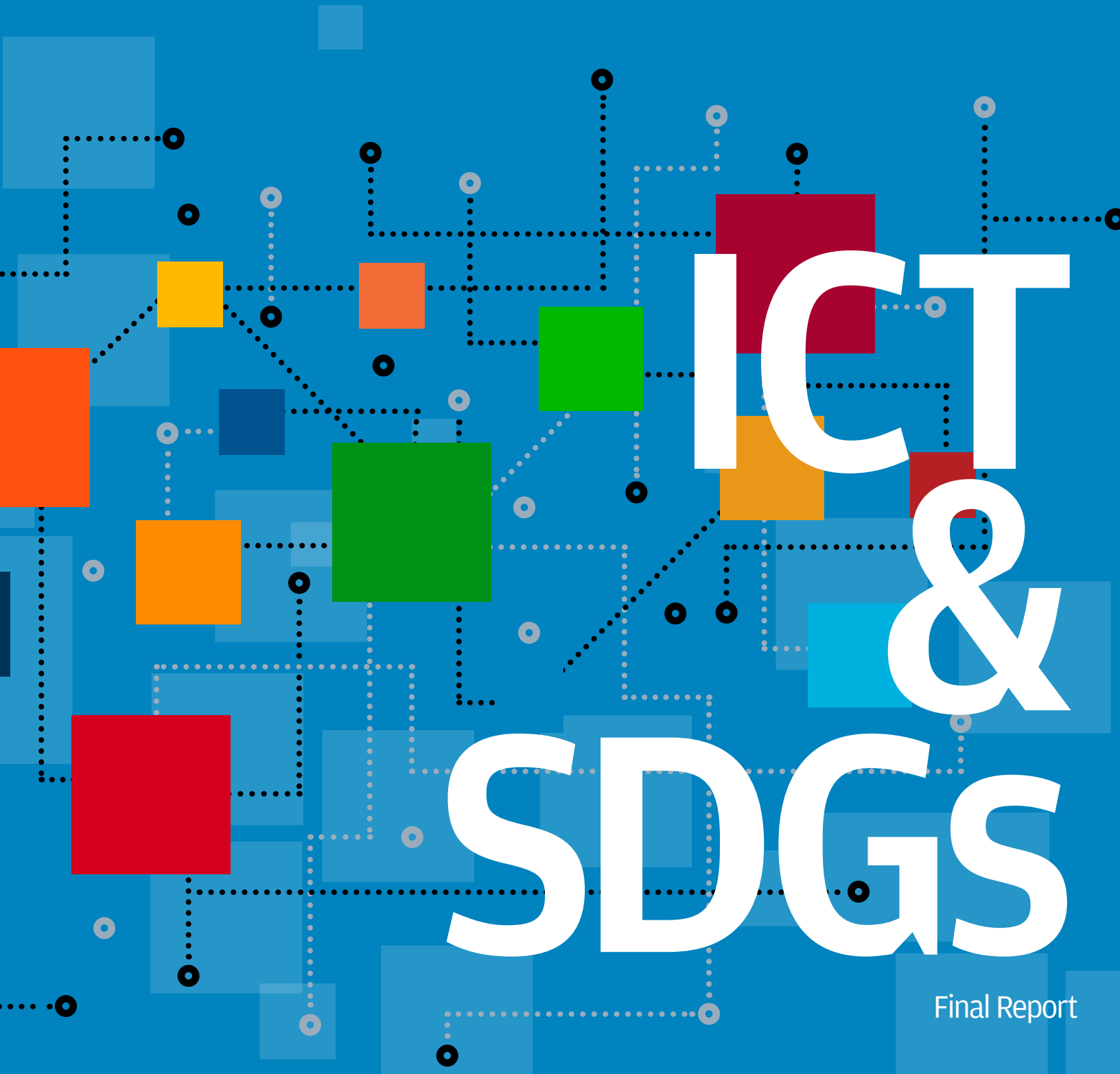
How Information and Communications Technology can Accelerate Action on the Sustainable Development Goals



ICT & SDGs

Final Report

The Earth Institute
Columbia University

ERICSSON

How Information and Communications Technology can Accelerate Action on the Sustainable Development Goals

ICT & SDGs

Final Report

About the Contributing Organizations

This report was produced by

The Earth Institute, Columbia University

By blending scientific research, education and practical solutions, The Earth Institute, Columbia University, is working to help guide the world onto a path toward sustainability. The Institute, under the direction of Professor Jeffrey D. Sachs, comprises more than 30 research centers and some 850 scientists, postdoctoral fellows, staff and students. Working across many disciplines, The Earth Institute studies and creates solutions for problems in public health, poverty, energy, ecosystems, climate, natural hazards and urbanization. For more updates on the work, follow @earthinstitute on Twitter.

Ericsson

Ericsson is the driving force behind the Networked Society—a world leader in communications technology and services. Our long-term relationships with every major telecom operator in the world allow people, business and society to fulfill their potential and create a more sustainable future.

Our services, software and infrastructure—especially in mobility, broadband and the cloud—are enabling the telecom industry and other sectors to do better business, increase efficiency, improve the user experience and capture new opportunities.

With approximately 115,000 professionals and customers in 180 countries, we combine global scale with technology and services leadership. We support networks that connect more than 2.5 billion subscribers. Forty percent of the world's mobile traffic is carried over Ericsson networks. And our investments in research and development ensure that our solutions—and our customers—stay in front.

Founded in 1876, Ericsson has its headquarters in Stockholm, Sweden. For more information, please visit www.ericsson.com. Follow Ericsson on Twitter: @Ericsson.

Contributing organizations

GSMA

The GSMA represents the interests of mobile operators worldwide, uniting nearly 800 operators with more than 250 companies in the broader mobile ecosystem, including handset and device makers, software companies, equipment providers and Internet companies, as well as organizations in adjacent industry sectors.

GSMA Mobile for Development brings together our mobile operator members, the wider mobile industry and the development community to drive commercial mobile services for underserved people in emerging markets. We identify opportunities for social, economic and environmental impact and stimulate the development of scalable, life-enhancing mobile services. Mobile is the predominant infrastructure in emerging markets. We believe it is the transformative technology that enables us to put relevant, impactful services into the hands of underserved people. Since the creation of GSMA Mobile for Development we have partnered with 50 mobile operators, rolling out 104 initiatives, impacting tens of millions of people across 49 countries.

www.gsma.com. Twitter: @GSMA.

ITU

ITU (International Telecommunication Union) is the leading United Nations agency for information and communication technologies, driving innovation in ICT together with 193 Member States and a membership of over 700 private sector entities and academic institutions. Established over 150 years ago in 1865, ITU is the intergovernmental body responsible for coordinating the shared global use of the radio spectrum, promoting international cooperation in assigning satellite orbits, improving communication infrastructure in the developing world, and establishing the worldwide standards that foster seamless interconnection of a vast range of communications systems. From broadband networks to cutting-edge wireless technologies, aeronautical and maritime navigation, radio astronomy, oceanographic and satellite-based earth monitoring as well as converging fixed-mobile phone, Internet and broadcasting technologies, ITU is committed to connecting the world. For more information, please visit www.itu.int. Follow ITU on Twitter: @ITU.

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Foreword

Professor Jeffrey D. Sachs

Jeffrey D. Sachs, Director of the Earth Institute and Special Advisor to United Nations Secretary-General Ban Ki-moon on the Sustainable Development Goals

Between 2001-2015, I had the great honor to be Special Advisor to the UN Secretaries-General Kofi Annan and Ban Ki-moon on the Millennium Development Goals (MDGs), aimed at fighting extreme poverty, hunger and disease. I now have the great privilege of continuing in this role as Special Advisor to Secretary-General Ban Ki-moon on the new Sustainable Development Goals (SDGs). During this time, I have felt enormously encouraged by two factors—the revolution in Information and Communications Technology (ICT) and the remarkable corporate leadership being shown by companies like Ericsson which is paving the way for a new Information Age.

ICT is the most powerful new tool we have for solving the world's major challenges—ending poverty and hunger, ensuring universal access to basic services, and making the transition to a low-carbon economy. Past generations were empowered by steam engines, the telegraph, automobiles, aviation and mass communications. Ours benefits from the extraordinary surge of information brought by the Internet and the breakthroughs, immediacy and flexibility enabled by mobile broadband—the main focus of this report.

A tool for the common good

Yet technology by itself is never a solution. It must be properly deployed—directed towards social purposes—and extended to the poor and to remote regions that markets alone will not serve, at least not in a timely way. Put simply, technology must be combined with a will towards the common good. In our era, that means harnessing it to the global objectives embodied by the MDGs and SDGs. For that, we require truly visionary corporate leadership, when and where it matters.

The Earth Institute and Ericsson are not only partners on this report, but have been partners in deploying ICT—especially mobile broadband—since the early days of the MDGs. Ericsson brought mobile connectivity and broadband to some of Africa's more remote rural areas a decade ago. Working together, the Earth Institute and Ericsson showed how mobile broadband could be successfully deployed to empower Community Health Workers. We showed how mobile broadband could help to get more children into school and keep them there, thanks to an improved curriculum. Our partnership on Connect to Learn is now benefiting not only high-school students—especially young women—in Africa, but in many other parts of the world. When the recent Ebola crisis struck, Ericsson again proved the power of technology tied to social purpose by equipping Community Health Workers in Guinea with connectivity and smartphones to enable contact tracing and help bring the epidemic to an end.

> Technology must be combined with a will towards the common good.

Now, along with many other partners, Ericsson and the Earth Institute are helping to lead on the SDGs. ICT and broadband are being deployed with strong social purpose to deliver improvements in health, education, payments, business development, agricultural production—and even peace-building in South Sudan and beyond.

We have co-authored this report together with contributions from the GSMA, representing the interests of mobile operators worldwide, and the International Telecommunication Union (ITU), the UN specialized agency for ICT. We share the strong belief and confidence that the SDGs can be achieved, that wireless broadband will be a key force for acceleration, and that leading companies, governments, academia, civil society and the UN agencies can step up as partners to deliver on the SDGs—above all, for the poor, the marginalized and the planet.

Foreword
Hans Vestberg

Hans Vestberg
President and CEO, Ericsson

Digital transformation is enabling rapid change in every industry and across every aspect of our lives. As a direct result of three fundamental ICT forces—mobility, broadband and the cloud—a new service economy is emerging where value chains are being reshaped, business models are becoming digitalized, distance is being overcome and increasingly, people can share goods and services instead of buying and owning them—all examples of how the digital age is unleashing innovative new business models and changing lives.

As innovation transforms the world around us, business is changing too and among the most significant demonstrations of this is the way companies like Ericsson are working with others to achieve shared societal goals and collectively tackle global challenges.

This year, Ericsson celebrates its 140th anniversary. During our history we have transformed many times, from enabling infrastructure which connected places with fixed phones, to connecting people through mobile telephony, to envisioning the architecture for today's Networked Society where everyone and everything is connected. But we have always been driven by the same objective—using communication to improve people's lives. In the late 1890s our founding father, Lars Magnus Ericsson coined the phrase that "access to communication is a basic human need." Today, this underpins our vision of being a relevant and responsible driver of positive change by using Technology for Good.

As an industry leader, our ideas, technology and people have had real impact, helping to transform lives, industries and society as a whole. As the world embarks on the ambitious journey of achieving the 17 Sustainable Development Goals (SDGs), it is our responsibility to work with other stakeholders to extend the benefits of communication by ensuring they are affordable and accessible to all.

Information Communication Technology (ICT) offers an incredible platform for achieving the SDGs. Every goal—from ending poverty and halting climate change to fighting injustice and inequality—can be positively impacted by ICT. As we suggest in this report, the digital revolution currently underway is paving the way for an Age of Sustainable Development—a profound transformation of society where technology is a key contributor to human and planetary wellbeing.

Information Communication Technology offers an incredible platform for achieving the SDGs.

This report is part of a shared, ongoing effort to make the benefits of broadband as a tool for sustainable development more widely known. When the Millennium Development Goals were set in 2000, broadband was in its infancy, with just 750 million mobile subscriptions worldwide. The latest Ericsson Mobility Report shows that there are now over 7 billion mobile subscriptions globally and that over 90 percent of the world´s population will be covered by mobile broadband networks by 2021.

As the inspiring case studies in this report show, universal connectivity offers a powerful platform to deliver essential services like e-governance, education, health, energy and financial inclusion and ensure that no-one is left behind. The report builds on the work of the Broadband Commission for Sustainable Development, a forum Ericsson has been deeply engaged in since its launch in 2010.

As argued in this report, ICT will be key to accelerating achievement of the Global Goals. By embracing broadband as a critical infrastructure for the 21st century, governments are creating the foundations for unprecedented global social and economic progress. Strong partnerships like our collaboration with the Earth Institute at Columbia University and my involvement in the newly formed Business Commission for Sustainable Development illustrate the type of engagement needed to reach the Goals.

Together, we can demonstrate that realizing significant long-term economic rewards goes hand-in-hand with helping to achieve the Sustainable Development Goals by 2030.

An ambitious new global agenda

The new Sustainable Development Goals, or SDGs, set out a shared global agenda for human development based on prosperity, social inclusion and environmental sustainability. The SDGs include several bold objectives to be achieved by the year 2030, including universal coverage in health, education, poverty eradication and modern energy services. This is the 2030 Agenda.

These global goals are even more ambitious than the Millennium Development Goals (MDGs). The MDGs helped to halve extreme poverty, the SDGs aim to end it. The MDGs focused on the poorest countries, the SDGs engage all nations in a shared, universal agenda. The MDGs prioritized prosperity and inclusion: this time, environmental sustainability is also addressed as a fundamental pillar of global wellbeing. These goals are achievable, but they require a breakthrough in both the speed and degree of progress.

Meeting these global 'stretch' goals calls for a transformation of societies far deeper and faster than in the past—a rate of change that a Business-As-Usual (BAU) approach simply cannot deliver. The 2030 Agenda also requires far greater engagement of the private sector, in particular in the provision of technological solutions that can deliver change in prioritized areas. Governments need to harness all the tools at their disposition—technology, investment, policy and partnerships—as key means of implementation to deliver the necessary step change in trajectory.

ICT is a game-changer

The key accelerator technology that can get us off the BAU path is Information and Communications Technology (ICT)—notably mobile broadband—which has demonstrated the fastest, most global technology uptake in human history. In future rapid innovation around the Internet of Things, advanced robotics, artificial intelligence and big data promise further substantial gains across the entire global economy.

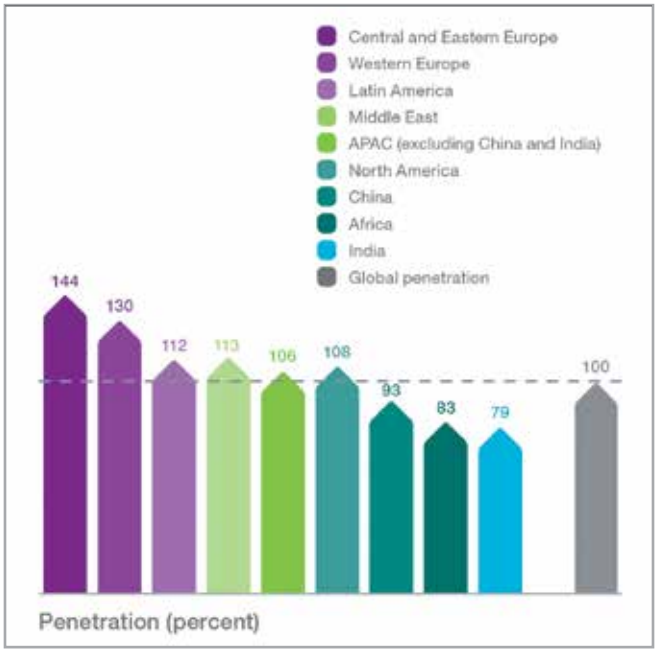
According to projections by Ericsson Mobility Report, mobile broadband (3G or above) will cover more than 90 percent of the world´s population, leaping from almost one billion subscribers in 2010 to 7.7 billion subscriptions by 2021[1] (total mobile subscriptions will be 9.1 billion). By the end of 2015, the total number of mobile subscriptions had reached 100 percent penetration at around 7.3 billion (see Figure 1)—the same number of mobile subscriptions as people in the world.[2]

Despite the gains, 4 billion people from developing countries were still not using the Internet.[3] However, this staggering ability to scale fast will help overcome the challenges of 'connecting the unconnected' and reaching the 'last mile' to deliver unprecedented social and economic inclusion—the focus of Chapter 3.

ICT, especially mobile broadband, will be **the essential infrastructure platform** for the SDGs. While this is recognized in the 2030 Agenda for Sustainable Development, where the terms 'technology' and 'technologies' appear at least 50 times and ICT is explicitly cited, the full potential of ICT is neither systematically nor adequately reflected in the individual goals and subsequent targets. Rapid action is needed to harness the contribution that ICT can make toward the achievement of the Global Goals. As Paragraph 15 of Agenda 2030 notes:

"The spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to devel-

Figure 1. The total number of mobile subscriptions globally, 2015



Source: Ericsson Mobility Report, February 2016

op knowledge societies, as does scientific and technological innovation across areas as diverse as medicine and energy."

Specifically, ICT has immense potential to speed up and scale—or *increase the rate of diffusion* of—a very wide range of cutting-edge technologies, applications and platforms across the economy, helping low-income countries to leapfrog to achieve key development milestones while contributing to a growth economy. Significantly, it can also dramatically reduce the costs of service delivery.

Fully embracing the potential of ICT is therefore a key ingredient to achieving the SDGs by their target date of 2030, and possibly to even accelerating their achievement.

Five ways ICT can help

According to the OECD, "more ubiquitous access to and use of broadband Internet networks, which are available in a competitive market and at affordable prices, will help foster innovation and drive the growth of the Internet Economy and the economy in general."[4]

To achieve the SDGs ICT needs to be combined with innovative policies, services and solutions to deliver transformation at unprecedented speed and scale. It can be a powerful means of implementation in five major ways:

1. Accelerated upscaling of critical services in health, education, financial services, smart agriculture, and low-carbon energy systems.

2. Reduced deployment costs addressing urban and rural realities.

3. Enhanced public awareness and engagement.

4. Innovation, connectivity, productivity and efficiency across many sectors.

5. Faster upgrading in the quality of services and jobs.

ICT can bridge institutional gaps by integrating informal trade into formal frameworks, strengthening economic development and reducing trade barriers. African Export-Import Bank (Afreximbank), for example, estimates that a mobile payment platform would bring into the formal sector around USD 50 billion of informal regional trade, with attendant benefits to governments, businesses and trade financiers. It can also reduce transaction costs: one in seven Africans (120 million) receives remittances from friends and family abroad, representing USD 60 billion and as much as a third of total GDP[5] in some markets.[6] Yet Africans pay the highest transaction fees in the world.[7] Chapter 5 describes how new, low-cost e- and mobile banking business models are disrupting this.

Lessons from key SDG focus areas

ICT has the power to deeply transform the economy as a whole, creating what Ericsson has termed the 'Network Society'. There are many aspects of society in which technology diffusion can be accelerated in support of the SDGs, in areas such as healthcare, education, financial services, energy and combatting climate change. To show the potential of ICT to drive progress on the SDGs, Chapters 5-8 of this report summarize lessons to date and explore the future outlook for four of these areas:

- Financial Services
- Education
- Health
- Energy and climate change

Groundbreaking case studies featured in this report show that the breakthroughs needed to drive and accelerate progress beyond Business-As-Usual (BAU) to meet the SDGs are already in operation, albeit on a small scale. The exciting hallmark of ICT is that it makes rapid scale-up of today's demos to tomorrow's national programs both feasible and realistic. In each case ICT offers potential for widespread, accelerated uptake by:

- Reducing the unit costs of service delivery;
- Expanding the range of services that can be offered;
- Economizing on scarce resources (e.g. by upskilling local workers online); and
- Accelerating institutional learning through online communities.

Issues and Challenges

No technology is without risks and widespread uptake of ICT raises a number of issues that will need to be addressed and managed. Several issues have been identified which governments, industry and other stakeholders must work together to address:

1. Privacy and surveillance
2. Cybersecurity
3. Loss of human skills
4. Possible public concern about health effects
5. Electronic waste and carbon emissions
6. Digital exclusion
7. Child protection and the Internet

These are explored further in Chapter 9. With appropriate public policies, the downsides of ICT can be mitigated to deliver substantial positive impact.

ICT-ready institutions

Governments, academic institutions, businesses and citizens must prepare for this ICT-enabled transformation by adopting the right policies, investing in broadband connectivity, ensuring adequate training, and innovating and partnering to incubate scalable solutions. The central role of policymakers in mobilizing national collective action to leverage ICT for digital transformation is a core focus of this report[8].

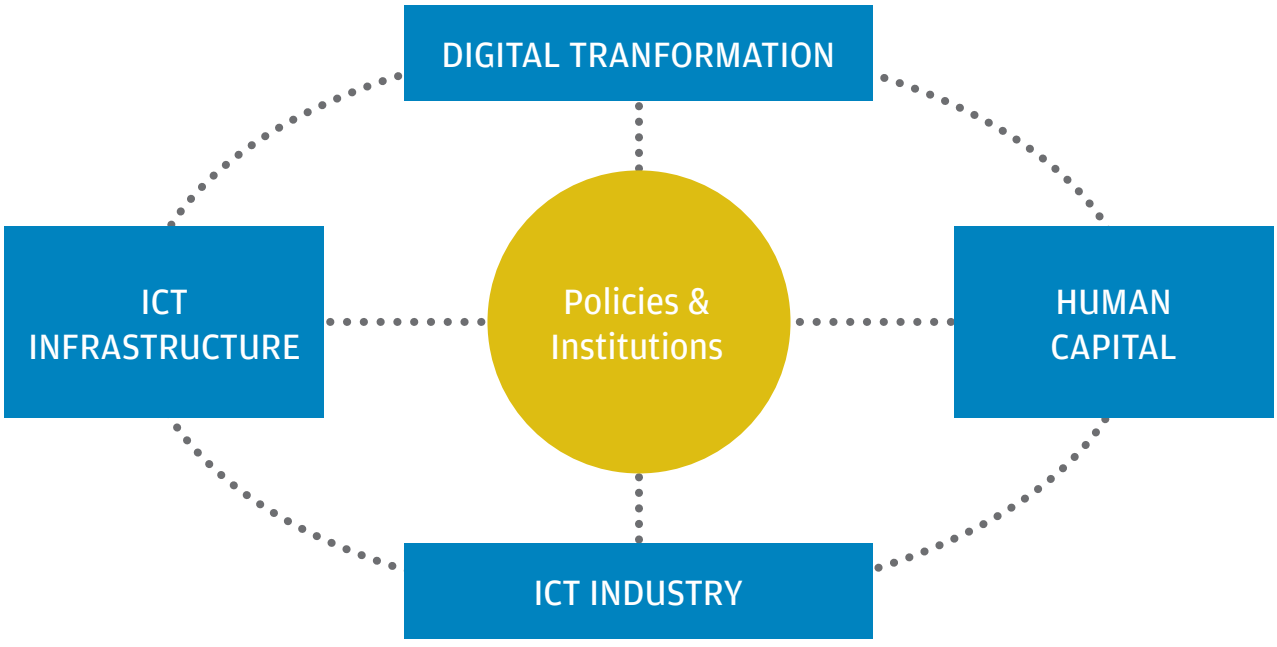
Rapid and successful ICT deployment depends on a number of elements, as shown in Figure 1. Of central importance are the policies and institutions shaping the ICT system: these govern rollout of physical infrastructure such as the fiber/microwave backbone and wireless access network (left); they influence the ICT and general skills of the workforce (right); they determine local operating presence of the ICT industry (bottom); and impact the readiness of key sector actors to adopt ICT solutions (top).

Making ICT the backbone of the economy

To fulfill its potential as a disruptive, transformative technology for good and deliver on the SDGs, ICT must be integrated into every facet of public policy and economic activity. To achieve this a number of hurdles must be overcome:

- Public sector regulations do not currently enable full utilization of ICT.
- Mobile broadband physical infrastructure needs rapid expansion and upgrading, especially to public facilities like schools and clinics.
- More public-private partnerships are needed to incubate new ICT start-ups to provide locally appropriate services.
- Small, fragmented demonstration projects require national scale-up with business models addressing urban and rural areas.
- ICT-based system components need to be interoperable across competing platforms.
- Significant training of personnel is required to manage ICT systems.
- Policy and regulation must play catch-up with rapid ICT innovation and deployment to ensure that new challenges, risks and threats are effectively managed.

Figure 2. The Interconnected Components of Successful ICT Deployment



Source: Hanna, Transforming to a Networked Society, Guide for Policy Makers, 2015.

Conclusions and recommendations

The main policy conclusion of this report is that to make the leap from a BAU path to an SDG path and deliver on the 2030 vision, governments need to equip the entire public sector—including service delivery in finance, education, health, energy and transportation—with high-quality ICT infrastructure. In addition to the recommendations in Chapter 11, action in the following six areas is needed to create an enabling framework:

1. **Broadband by 2020:** Establish a timeline for universal broadband connectivity of public facilities and services—no later than 2020.

2. **Enabling policy framework:** Adopt the 10 recommendations for multi-stakeholder action from the UN Broadband Commission Task Force on Sustainable Development[9] and develop enabling policies that address supply- and demand-side issues (see Chapter 11), while protecting the right to privacy and freedom of speech.

3. **Rapid ICT rollout:** Drive integration of ICT throughout the public sector—across governance, public administration and provision of public services, including health, education and infrastructure to ensure the foundation for digital transformation.

4. **Public-Private Partnerships (PPP):** New partnerships are needed between government, international organizations and industry in order to find sustainable business models that support wide-scale ICT deployment. For example, to connect the unconnected in areas that are not currently profitable, or to accelerate the creation of innovation hubs to develop new ICT applications—especially locally designed and targeted ones. Sufficient public and private investment needs to be actively targeted towards ICT. Business models need to address the needs of urban and rural areas.

5. **Upgrade STEM:** Foster science, technology, engineering and mathematics skills in primary and secondary education to build long-term technology readiness and scale up ICT training programs with universities.

6. **Harness big data:** Create national online and open databases using big data from public service provision and satellites, mobile networks, remote sensors and other connected devices in the Internet of Things.

The SDGs represent a complex, global problem-solving exercise that cuts across all sectors of society. To deliver on this shared vision by 2030, we must deploy all available tools—including ICT—by putting in place now the necessary frameworks for success.

Introduction: ICT and the SDGs

The new Sustainable Development Goals (SDGs), set out a shared global agenda for human development that is fair, inclusive and sustainable. Far more ambitious than the Millennium Development Goals, they call for several bold breakthroughs by the year 2030, including the end of extreme poverty (SDG 1) and hunger (SDG 2), universal health coverage (SDG 3), universal secondary education (SDG 4), universal access to modern energy services (SDG 7), sustainable cities (SDG 11), combating climate change (SDG 13), and protecting marine (SDG 14) and terrestrial (SDG 15) ecosystems.[10]

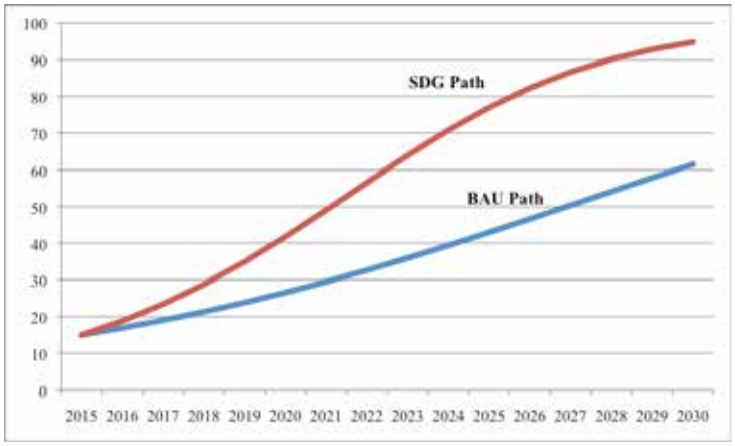
Meeting these 'stretch' goals will require a transformation of societies far deeper and faster than in the past—a rate of change that continued economic growth in a Business-As-Usual (BAU) context simply cannot deliver. To succeed, the SDGs must embed the values that underpin inclusive transparent societies and rapidly leverage innovative policies, technologies, services and solutions with vastly improved reach to meet ambitious global targets while ensuring no-one is left behind.

Information and communication technology (ICT) is an existing and widely deployed technology that can be mobilized to step up the pace and scale of transformation. The central role ICT can play in delivering innovative, integrated, cross-sectoral sustainable development outcomes has been highlighted by the UN Broadband Commission for Sustainable Development.[11] In a series of reports, the Broadband Commission has made a strong case for harnessing the transformational potential of ICT and broadband as a means of implementation for the SDGs. Not only can ICT deliver innovation, connectivity, productivity and efficiency gains across many sectors, it can strengthen resilience of critical infrastructure and help to overcome social and economic exclusion.[12]

Beyond Business-As-Usual

Many of the SDGs call for the economy to reach *universal* coverage of some core service by 2030, e.g. healthcare (SDG 3), pre-primary up to secondary education (SDG 4), access to safe water and sanitation (SDG 6), and access to reliable electricity (SDG 7). In most low-income countries, a Business-as-Usual (BAU) path will not be sufficient to achieve these universal coverage goals by the target date of 2030. As illustrated in Figure 1, the BAU path will support partial achievement of the goals but will not deliver full achievement. The path to universal coverage must be accelerated, as shown by the SDG path in Figure 1. ICT-based solutions can be central to that acceleration if governments, universities and the private sector work in partnership towards this goal.

Figure 1. Comparison of BAU and SDG Paths



In this figure, two hypothetical pathways towards 2030 are illustrated, with 'Years' on the x-axis and 'Percent Achievement of Universal Coverage Goals' on the y-axis. Theoretically, the Business-As-Usual (BAU) path will support partial achievement of the goals and the SDG path will fully achieve the goals.

Why ICT, why now?

By 2021, over 90 percent of the world's population will be covered by mobile broadband networks.

Source: Ericsson Mobility Report 2015

ICT can be a crucial enabler in helping to achieve the SDGs, particularly in today's low-income countries where closing the development gap requires substantial effort, innovation and investment. In its infancy during the MDGs, mobile broadband is a rapidly evolving, 'leapfrog' technology now reaching maturity. In 2000, there were 700 million mobile subscriptions; today there are 7 billion.[13] Mobile broadband offers staggering gains in accessibility, scalability and affordability that can enable countries to close multiple development gaps at record speed,[14] without the outlay of traditional infrastructure.[15]

Figure 2. The Sustainable Development Goals

Figure 3. The Transistor Count on Intel Microprocessors, 1971-2012 (based on Intel data[16])

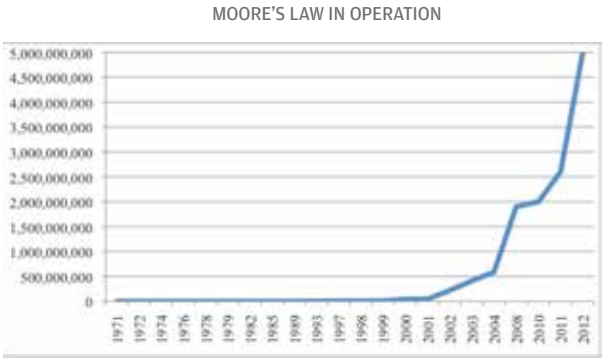


Figure 4. Price Index for Microprocessor Units (MPU), quality adjusted[17]

Note. Hedonic indexes are based on regressions that use SPEC performance to control for quality.

ICT has experienced the fastest global diffusion in history, with the time taken for the global public to adopt ICT-based applications such as mobile phones, computers, the Internet and social media outstripping any previous technology.

Thanks to Moore's Law—the doubling every two years of the number of transistors in a dense integrated circuit[18]—ICT has given rise to The Information Age, the fifth great technological age. Since the onset of the Industrial Revolution, each new wave of technology has provided a major impulse to global economic development (Figure 3). ICT has spurred global economic growth for the past three decades, but its greatest gains are yet to be achieved and are expected to pave the way for the Age of Sustainable Development—a sixth great wave of sustainable technologies that will make achievement of the SDGs possible.

Mobile connectivity has been able to scale at this pace due to the industry focus on global standards, interoperability and other factors. This has led to dramatic economies of scale, falling handset prices, etc., which has improved affordability.

The resulting surge in microprocessor performance and sharp decrease in unit cost has also contributed to high productivity growth in the ICT industry and rapid diffusion of ICT products.

Today there is near universal uptake of mobile telephony—mobile subscriptions in Africa have gone from almost no subscribers in 2000 to around 950 million today and by 2021, over 90 percent of the world's population will be covered by mobile broadband networks.[19] This global shift towards what Ericsson has termed the 'Networked Society' brings unprecedented opportunities to address global sustainable development challenges as ICT drives disruptive change across every sector of society.

Already, mobile phones are enabling dramatic breakthroughs in e-finance and e-health, overcoming longstanding gaps in access to facilities such as bank branches and clinics. In many parts of the world, ICT is transforming cost-intensive public services and paving the way for advances in e-commerce, governance, trade and transportation. Future advances in ICT—mobile broadband, the Internet of Things (IoT), robotics and artificial intelligence, 3-D printing, and others—will provide the tools for additional, unprecedented advances in healthcare, education[20], agriculture, energy services and environmental monitoring and protection.

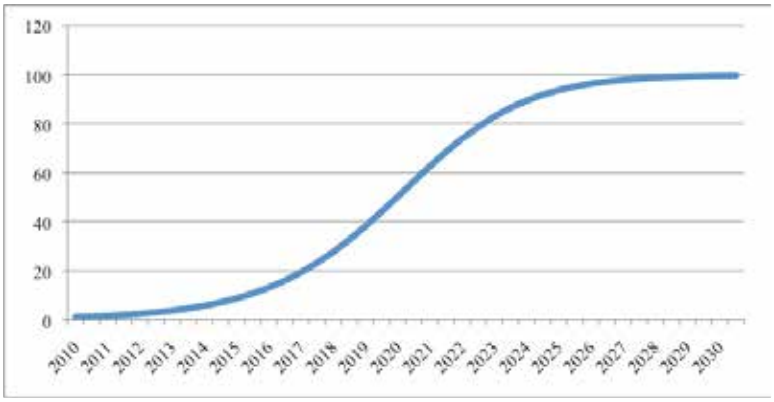
A rapid diffusion technology

Uptake or diffusion of a technology or service (such as electrification, secondary-level education, or primary health coverage) typically follows an S-shaped curve as in Figure 5. Use or penetration starts at a very low level and initially increases only gradually. After some time, uptake accelerates. As the coverage rate approaches 100 percent, growth will slow again and finally come to a halt when coverage is complete.

In the case of ICT, not only has its own diffusion S-curve been extraordinarily steep, but it has the potential to increase the rate of diffusion in other aspects of the economy too.

In short, ICT has the power to bring about a digital transformation of society as a whole. Specifically, it has extraordinary potential to *increase the rate of diffusion* of a very wide range of technologies, applications and platforms. Key areas in which technology and service diffusion can be accelerated via ICT include healthcare, education, financial services, energy and fighting climate change. Accelerated uptake of ICT-

Figure 5. Illustrative S-Shaped Technology Diffusion Curve



based services across these sectors will be key to achieving the SDGs by their target date of 2030.

Particularly in low-income countries, where a BAU path will not deliver universal coverage goals by 2030, together with the finance, frameworks, partnerships and policies recommended by the UN Broadband Commission Task Force on Sustainable Development, ICT can be a critical catalyst for rapid uptake of the innovative solutions needed to put the world on the SDG path and meet the goals.[21]

Mobile subscriptions went from a few tens of thousands in 1980 to over 7.4 billion subscriptions in 2015.

Source: Ericsson Mobility Report, November, 2015

The speed of diffusion of mobile telephony and now mobile broadband reflects certain critical characteristics of ICT technologies, including: (1) their rapidly declining costs; (2) business models that enable access of poor households to the technologies; (3) the remarkable range of low-cost or free applications; (4) the relative ease of building the hardware backbone (e.g. fiber network) and (5) the ability of wireless broadband to reach the 'last mile' through microwave transmission rather than physical cable.

Five ways that ICT can help

ICT can dramatically boost the uptake of SDG-supporting technology and services in five major ways:

1. Speed and scale of ICT uptake

As noted above, ICT itself diffuses with remarkable speed and at a global scale; the digital transformation has already begun. Mobile subscriptions went from a few tens of thousands in 1980 to over 7.4 billion subscriptions in 2015. Facebook users went from zero in 2004—the year the platform was launched—to 1.5 billion users in mid-2015. According to projections by Ericsson Mobility Report[22], mobile broadband (3G or above) will cover more than 90 percent of the world´s population and go from almost one billion subscribers in 2010 to 7.7 billion subscriptions by 2021. Smartphones will grow from near-zero subscriptions in 1999, when NTT DoCoMo introduced the first smartphone, to around 6.4 billion subscriptions by 2021. Piggybacking on ICT's staggering ability to scale will help with widespread inclusion and reaching the 'last mile'.

2. Reduced deployment costs

ICT can also markedly reduce the cost of deploying new services. In healthcare, for example, ICT makes possible a greatly expanded role for low-cost Community Health Workers (CHWs), enabling a large number of diagnoses and treatments to be made at community level during CHW visits rather than by doctors at high-cost facilities. In education, ICT enables students to access quality online teaching even when no qualified teachers are locally available. Online finance allows individuals to obtain banking services even in regions where no banks are present. These simple examples show how ICT is introducing vital services for the first time in low-income countries. Similarly in high-income countries, cost savings from ICT are already disrupting major sectors across the economy, enabling rapid, pervasive change.

3. Growth of public awareness

ICT can dramatically speed up public awareness of new services and technologies and therefore the demand and readiness for these. In the past, information on new technologies spread by word of mouth, local demonstration,

and gradual scale-up of government programs and services. Now, with torrents of information flowing in real time through the Internet, social media, mobile communications and other e-channels, information travels instantly around the globe, bar in the handful of societies isolated by closed regimes. News, music, fashion, fads and new technologies ricochet around the world in days, not decades, making it easier to reach more people in a shorter timeframe.

4) Rapid upgrade rate

National and global information networks enable rapid innovation and upgrading through new applications. All new technologies go through a learning curve during which they evolve incrementally through each generation of improvement. Every phase is marked in principle by lower costs, greater resilience, easier use, and wider applicability. ICT is speeding up these generational cycles. Global information flows are enhanced and technology developers are much more attuned to advances in other parts of the world. There is a trend towards many ICT applications becoming open-source—or at least interoperable—which enables gains made by a developer in one part of the world to be picked up and built on by others on the other side of the globe, accelerating the whole process of technology upgrade. The growing speed of the global innovation cycle is shortening the duration of each technology generation, especially for ICT-based solutions, meaning progress happens faster.

5) Low-cost digital training

The final way that ICT can accelerate technology diffusion is by providing low-cost online platforms for training workers, students and others in these new technologies. The revolution of Massive Open Online Courses (MOOCs), for example, enables students anywhere to gain free access to high-quality university courses, including courses in design and use of ICT. Special training materials are also being delivered conveniently over smart phones, tablets, laptops and other devices. Deploying multiple channels for training materials makes it easier to provide workers with real-time, in-service training that does not disrupt work schedules but integrates training into the work itself. In this way, ICT-hosted training modules and courses provide a means to train millions of workers, especially young and under-employed workers, in the uses of new ICT applications for SDG-oriented service delivery.

Lessons from key SDG focus areas

To illustrate the potential of ICT to drive and accelerate progress on the SDGs beyond Business-As-Usual (BAU), this report summarizes lessons to date. Broadband is a key enabling infrastructure for all aspects of the economy and to illustrate how, this report explores the future outlook for four key SDG focus areas: health, education, financial services, and energy and climate change. In each case ICT offers potential for widespread, accelerated uptake by:

- reducing the unit costs of service delivery;
- expanding the range of services that can be offered;
- economizing on scarce resources (ICT can be used to upskill local workers, who can be trained online rather than having to send a trainer to a physical location; and
- accelerating institutional learning through online communities.

In general, the case studies in this report point to an exciting future. Many of the breakthroughs needed for the SDGs are already in operation, albeit on a very small scale. The good news is that ICT, by its very nature, makes rapid scale-up of today's demos to tomorrow's national programs both feasible and realistic.

The case studies also highlight the many practical hurdles to effective large-scale implementation of state-of-the-art e-health, m-health, m-commerce, e-education and smart energy and transportation services, where:

- public sector regulations do not yet enable full utilization of ICT;
- numerous small, fragmented demonstration projects need to be successfully scaled into national-scale programs with business models addressing urban and rural areas;
- the physical infrastructure for wireless broadband needs rapid expansion and upgrading, especially to public facilities like schools and clinics;
- the various components of an ICT-based system need to be interoperable across several competing platforms;
- significant training of personnel is required to manage the new systems; and
- incubation of new ICT start-ups capable of providing locally appropriate services needs to be nurtured under public-private partnerships.

Creating an enabling environment

Fulfilling the SDGs calls for multi-sectoral partnerships, as described in SDG 17, and governments, investors, academic institutions, businesses and citizens need to collaborate and prepare for ICT-enabled transformation to a Networked Society. While private-sector applications of ICT have soared, many of the challenges of sustainable development—health, education, infrastructure and environmental sustainability—require a deep role for policymakers and the public sector to drive progress by 2030.

Governments and policymakers have a special responsibility to ensure that ICT is included in urban and rural planning as a basic infrastructure and that key public–sector agencies, institutions and policy frameworks are reformed to support ICT-enabled transformation. Many government processes—payments, tax collection, procurement, training, human resources, program design, public deliberation, information management, analytics, legislative drafting, even voting—should be upgraded with the transformative capability of ICT in focus. Institutional quality will increasingly be defined by how effectively entities fulfill the vision of the SDGs by adopting cutting-edge solutions that facilitate provision, transparency, openness and efficiency, as well as high throughput of public services. In a fully Networked Society, more efficient, cost-effective ICT-enabled services and transactions will lead to the transformation of skills and the creation of new jobs. Ensuring that no-one is left behind will be critical in this period of transformation.

To harness ICT effectively for the 2030 Agenda and move away from Business-As-Usual, governments need to ensure that the entire public sector, including service delivery in health, education, energy, and infrastructure, is fully supported by high-quality ICT infrastructure. This could include:

- Promoting ICT as a basic infrastructure in urban and rural planning and investment
- Broadband connectivity of all public facilities by 2020.
- ICT training of all relevant public officials and service providers.
- ICT-based delivery systems for healthcare, education and infrastructure.
- Deployment of the Internet of Things (remote sensing and control of connected devices) for public infrastructure and environmental management.
- Encouragement of universities to scale up education and incubation of ICT solutions, including through partnerships with the business sector.
- Public-Private Partnerships (PPP) for ICT-enabled systems.
- Adoption of state-of-the-art indicators and real-time data collection to track progress against the SDGs.

At the epicenter of the societal transformation process, national governments and policymakers have a key role to play in ensuring effective uptake and adoption of ICT. Without supportive government policy, the private sector cannot drive rapid growth of ICT at scale. Governments are accountable for the policies and legislative framework governing the deployment of ICT. They oversee land use, allocation of spectrum, right-of-way for fiber and other infrastructure, and the tax and regulatory policies that will ultimately determine the speed of rollout of the ICT backbone and access networks, the flourishing of service providers, and the uptake of ICT-based solutions in essential public services as well as efficient governmental funding systems.

Against a backdrop of pressing global challenges, an ambitious global development agenda, and rapid ICT-enabled transformation, standing still is the biggest enemy. Technology has evolved much more rapidly than policy, underscoring the need to close the gap, so that the technology can be fully leveraged. From this perspective, policymakers need to act rapidly to address the issues and challenges identified in Chapter 9, and mobilize the investment, policies, technology and partnerships needed to drive national collective action in line with the conclusions and recommendations in Chapter 10 and Chapter 11.[23] With the right frameworks and policies in place, ICT can help deliver the transformative change the world needs to meet our ambitious shared development goals and ensure no-one is left behind.

1

ICT: A catalyst for achieving the SDGs

What are the SDGs?

Adopted by world leaders at the United Nations Sustainable Development Summit on 25 September 2015, the 2030 Agenda for Sustainable Development includes 17 Sustainable Development Goals (SDGs) and 169 associated targets to end poverty, fight inequality and injustice, and tackle climate change by 2030. Also known as the Global Goals, the SDGs build on eight anti-poverty targets—Millennium Development Goals (MDGs)—that the world committed to achieving by 2015. The new SDGs go much further to address the root causes of poverty and universal need for development that works for all. In addition to ongoing development priorities such as poverty eradication, health, education, food security and nutrition, they set out a broad range of interconnected economic, social and environmental objectives including more peaceful and inclusive societies. Global and universally applicable, the goals take into account different national realities, capacities and levels of development as well as defining means of implementation.

The 2030 Agenda for Sustainable Development fundamentally recognizes that "the spread of information and communication technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies". While none of the SDGs is specifically about ICT, several targets refer to ICT and technology, and ICT will underpin the achievement of every goal. All three pillars of sustainable development—economic development, social inclusion and environmental protection—need ICT as a key catalyst; and ICT, particularly broadband, will be absolutely crucial for achieving all 17 SDGs. Here are some of the ways we envision the role of ICT in accelerating the achievement of the SDGs:

End poverty

ICT is key to helping end poverty by providing possibilities to improve productivity among millions of people so that they can better provide for themselves and their families and move out of poverty. This can occur in many ways, for example, by providing timely and accurate information services to help ensure equal rights to economic resources, as well as enabling services such as mobile banking and micro-credit, and in helping small producers to find the best markets for their products.

End hunger & achieve food security

ICT can help to reduce hunger and increase food security by giving farmers direct access to market information, weather forecasts, as well as planting, harvesting and targeted irrigation advice, logistics and storage, thereby helping to increase yield, restore soil, reduce waste and improve both productivity and effectiveness.

Healthy lives & promote wellbeing

ICT can deliver substantial and significant benefits across the whole of the global healthcare ecosystem. Connectivity enables health workers to be connected to information and diagnostic services, while analytics can help make projections about disease outbreaks, health service usage, patient knowledge, attitudes, personal continuous management of diseases and health practices.

Ensure inclusive and equitable quality Education for all

ICT is helping to improve education globally, allowing students to access learning assets and teachers to prepare for classes anytime, anywhere.[24] ICT can assist in opening up access to education for all, particularly underserved populations and those living in remote, resource-poor areas. It also can deliver online certification and student advisory services, in turn leading to improved economic opportunities for all.

Achieve gender equality and empower all women and girls

ICT can enhance gender equality and gender empowerment, allowing women and girls to access information of importance to their productive, reproductive and community roles as well as involving women in urban planning. Women's sustainable livelihoods can be enhanced through expanded access to markets, education, training and employment.

Water & sanitation for all

ICT will be crucial in ensuring the availability and sustainable management of water and sanitation for all. ICT is particularly important in terms of smart water management, infrastructure location, better and lower-cost maintenance, optimized operations and improved quality of service to customers.

Ensure access to energy for all

ICT is already demonstrating its strong potential to improve energy efficiency and reduce emissions, both by making ICT itself more environmentally sound and less carbon-intensive, and through ICT-enabled solutions such as smart grids, smart buildings, homes and smart logistics that allow other sectors of the economy to improve their energy efficiency and lower energy consumption.

Economic growth, employment and decent work for all

ICT skills have become a prerequisite for many forms of employment in the 21st century. Digital technology is transforming the way that business is being done everywhere, from traditional employment sectors including farming, manufacturing and the health sector to new sectors such as offshore services. Moreover, ICT is important for economic and productivity growth. Recent research shows that a 10 percent increase in ICT capital services is associated with a 0.9 percent increase in GDP.[25]

Infrastructure, industrialization, innovation

ICT will continue to play an essential role in building and maintaining resilient infrastructure, in promoting inclusive and sustainable industrialization, and in fostering innovation in the emerging information and knowledge societies which depend on open access to academic research, transparency to make informed decisions and the power of online collaboration to support cross-sector and in-house co-creation, learning and work.

Reduce inequality

ICT can help reduce inequality within and between countries, especially when used to help bring information and knowledge, and therefore social and economic progress, to disadvantaged segments of society—including those living with disabilities, as well as women and girls.

Sustainable cities and communities

ICT is essential in offering innovative approaches to managing cities more effectively and holistically, with ICT basic infrastructure and applications such as smart buildings, smart water management, intelligent transport systems, and new efficiencies in energy consumption, resource waste management.

Sustainable consumption & production patterns

ICT can foster sustainable consumption and production through product-specific improvements, increased dematerialization and virtualization, and the implementation of smart technologies in sectors including agriculture, transportation, energy, supply chain management, and smart buildings.

Urgent action to combat climate change and its impacts

Smart ICT applications, particularly in the areas of, energy, transport and buildings, manufacturing (Industry 4.0), smart services and agriculture and urbanization in general,[26] can help tackle climate change and mitigate its impacts. ICT can optimize value chains, reduce resource usage and waste, and also plays a crucial role in sharing climate and real-time weather information, forecasting early warning systems as well as supporting resilience and climate adaptation.

Oceans, seas and marine resources

ICT can assist in oceanic conservation and sustainability. Satellite monitoring delivers timely and accurate global data, improving accountability, while big data can be used to analyze biodiversity, pollution, weather patterns and ecosystem evolution, and to help plan mitigation and adaptation strategies.

Halt and reverse land degradation

ICT can play a significant role in the conservation and sustainable use of terrestrial ecosystems and preventing biodiversity loss through improved monitoring and reporting, which leads to increased accountability, as well as through use of big data to analyze short- and long-term trends and plan mitigation activities. ICT also improves efficiencies in land restoration via sensors, data collection and analysis.

Peace, justice & strong institutions

Within crisis management, humanitarian aid and peacebuilding, ICT has proven to be a powerful tool in areas such as electoral monitoring, through the use of crowdsourcing. Government use of open data increases transparency, empowers citizens, and helps to drive economic growth.

Strengthen the means of implementation & partnerships for development

ICT is unique in its capability to specifically strengthen the means of implementation for the SDGs, through enhancing international cooperation and coordination; promoting technology transfer; capacity-building; forging multi-stakeholder partnerships; and enabling and improving data monitoring and accountability.

2 Monitoring progress: ICT indicators for the SDGs

2.1 Introduction

In the ambitious plan to eliminate poverty and hunger, protect the planet, combat inequalities and build peaceful, just and inclusive societies over the next 15 years, accurate data to monitor progress will be essential.

In March 2015, the United Nations Statistical Commission (UNSC) established an Inter-agency and Expert Group on SDGs (IAEG-SDGs[27]) composed of Member States and including regional and international agencies as observers, to propose a global framework for indicators.

In March 2016, the UNSC agreed on a global indicator framework[28] comprising 231 indicators to help monitor progress, identify challenges, and guide policymakers. The data will also provide the basis for an annual UN progress report. The Commission agreed that this framework would be a practical starting point and that the indicators included in the framework would require further technical refinements.

2.2. ICT indicators account for seven targets

The February 2016 version of the IAEG-SDGs report includes[29] the following seven ICT indicators covering seven targets under Goals 4, 5, 9, and 17 (along with the lead organization for tracking the indicator at the international level):

- Target 4a: Proportion of schools with access to the Internet for pedagogical purposes (UIS)
- Target 4a: Proportion of schools with access to computers for pedagogical purposes (UIS)
- Target 4.4: Proportion of youth/adults with ICT skills, by type of skills (ITU)
- Target 5b: Proportion of individuals who own a mobile telephone, by sex (ITU)
- Target 9c: Percentage of the population covered by a mobile network, by technology (ITU)
- Target 17.6: Fixed Internet broadband subscriptions, broken down by speed (ITU)
- Target 17.8: Proportion of individuals using the Internet (ITU)

2.3. Monitoring progress towards Goal 9 (Making ICT a basic infrastructure)

The indicators to track targets 4.4 and 5b are relatively new and more data is expected to become available over the next few years. This section examines what is known about the ICT indicators to track targets 9c, 17.6 and 17.8.

By 2015, 95 percent of the world's population and 85 percent of people living in the LDCs, were covered by a mobile-cellular signal; but only 29 percent of the population in rural areas had access to a mobile-broadband network.

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

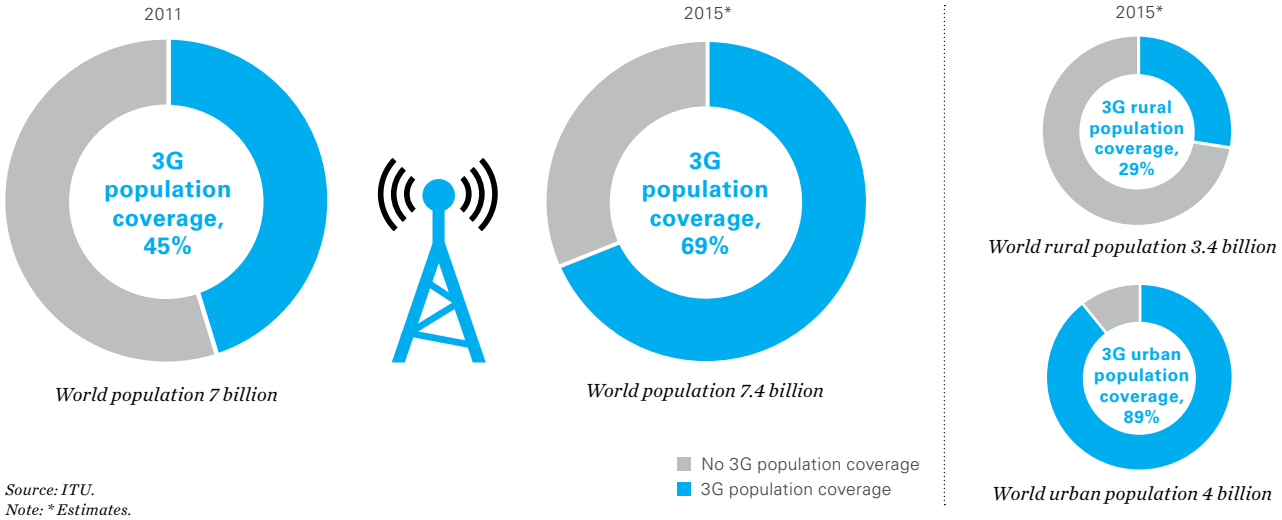
Target 9c: Significantly increase access to ICTs and strive to provide universal and affordable access to the Internet in least developed countries by 2020.

Indicator 9.c.1: Proportion of population covered by a mobile network, by technology

Technological progress and expanding networks, falling prices, and growth in applications and content have accelerated the growth of ICT. Mobile communications technology, in particular, has spread much faster than anticipated, enabling millions of people previously living in unconnected areas to join the Networked Society.

By 2015, second-generation (2G) mobile telephony was quasi-ubiquitous, with 95 percent of the world's population and 85 percent of people living in the Least Developed Countries (LDCs) covered by a 2G mobile-cellular signal. Third-generation (3G) mobile population coverage, which delivers higher speed access to the Internet and ICT services and applications, stood at 69 percent globally in 2015. In rural areas, only 29 percent of the population was covered, though, highlighting that mobile broadband access remains limited in many rural and remote parts of the world (Figure 2.1).

Figure 2.1: 3G mobile-broadband coverage, globally and urban versus rural



Source: ITU.
*Note: * Estimates.*

Source: ITU Facts and Figures 2015. Note: *Estimates.

ITU methodology for data collection

ITU collects data for the 'proportion of population covered by a mobile network, broken down by technology', which is based on an internationally agreed definition and methodology, through an annual questionnaire from national regulatory authorities or Information and Communication Technology Ministries, who collect the data from mobile operators. By 2014, data on 2G mobile population coverage were available for about 144 countries, from developed and developing regions, and covering all key global regions. Data on 3G mobile population coverage was available for 135 countries. This data was used to produce 2015 global estimates. ITU produces global estimates for the rural population coverage, by technology, based on the data for the percentage of the population covered by a mobile network, broken down by technology, and on rural population figures.

Fixed-broadband penetration in Least Developed Countries (LDCs) remains negligible and major differences in terms of the quality and speed of Internet access must be addressed to fully benefit from the potential of ICT for development

Goal 17: Strengthen the Means of Implementation & Revitalize the Global Partnership for Development

17.6: Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the UN level, and through a global technology facilitation mechanism

17.6.2: Fixed Internet broadband subscriptions per 100 inhabitants, by speed

2.4. Monitoring progress towards Goal 17 (Global Partnership for Development)

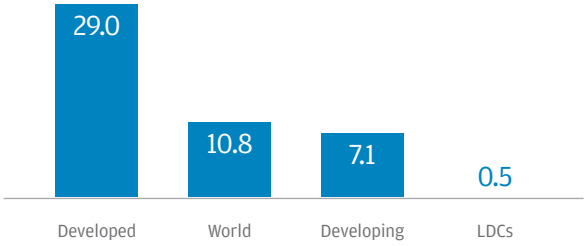
High-speed Internet access can enhance international cooperation on, and improve access to, science, technology and innovation, and help share knowledge. However, limitations in the capacity and speed of fixed-broadband connections will affect the quality and functionality of this Internet access. Mobile cellular and mobile-broadband networks have spread rapidly across developed and developing regions, but fixed-broadband services remain largely unaffordable and unavailable across large segments of the developing world's population. With mobile broadband, it is possible to leapfrog to new technologies that can overcome these challenges, at a fraction of the cost.

By 2015, fixed-broadband penetration reached 29 percent in developed countries, but only 7.1 percent and 0.5 percent in developing countries and LDCs, respectively (Figure 2.2). These differences highlight the digital divides in access to high-speed, high-capacity broadband. In addition, inequalities are accentuated by differences in the speed of available fixed broadband connections.

While by 2015 most developed countries had primarily fixed-broadband connections with speeds of over 10 Mbit/s, most developing countries do not have any connections that exceed 2 Mbit/s broadband speed. If not properly addressed, the digital divide risks aggravating inequalities that will hinder achievement of the SDGs.

Figure 2.2: Percentage of fixed broadband subscriptions by development status, 2015 estimates

Source: ITU Measuring the Information Society Report 2015 Note: *Estimates.



Note: The gap represents the difference between the Internet user penetration rates for males and females relative to the Internet user penetration rate for males, expressed as a percentage.

ITU methodology for SDG 17 (Global Partnership for Development)

ITU collects data for this indicator through an annual questionnaire from national regulatory authorities or Information and Communication Technology Ministries, who collect the data from Internet service providers. 2014 data was available for about 80 economies, from developed and developing regions, and covering all key global regions. Data on fixed-broadband subscriptions (not broken down by speed) exists for almost 200 economies in the world. 2014 country data was used to produce 2015 global estimates.

17.8: Fully operationalize the technology bank and science, technology and innovation capacity-building mechanism for LDCs by 2017 and enhance the use of enabling technology, in particular ICT

17.8.1: Proportion of individuals using the Internet

Internet access has grown substantially over the last decade and by 2015, 3.2 billion people globally were online. While in developed countries about 80 percent of the population was using the Internet, one third of the population in developing countries was online. Only one out of ten people in the LDCs are currently using the Internet (Figure 2.3).

In 2015, 4 billion people from developing countries were still not using the Internet, and more men than women were online, with Internet user penetration rate about 11 percent lower for females than for males, globally.

Sex-disaggregated data for Internet use shows that there is an important gender digital divide. In 2015, the Internet user penetration rate was about 11 percent lower for females than for males, globally. The gap between the two rates is significantly higher in developing countries and highest in LDCs (Figure 2.4).

Figure 2.3: Internet users, 2015*

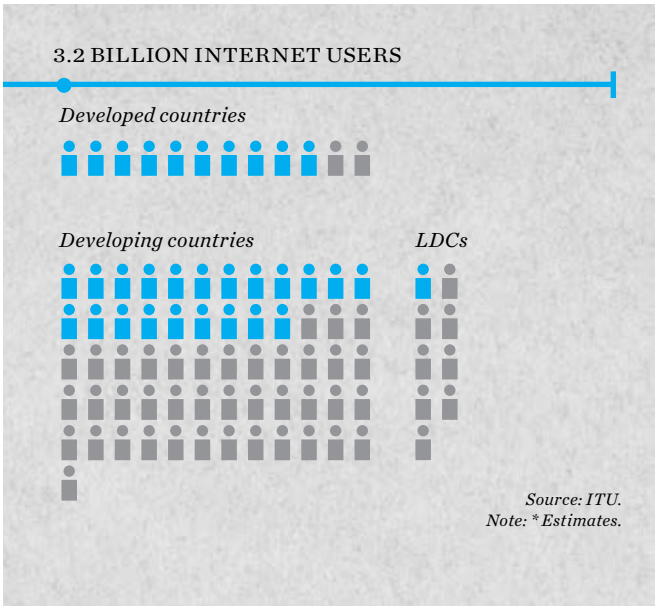
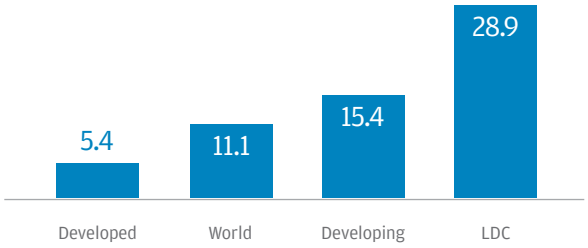


Figure 2.4: Gap in Internet user penetration rate between males and females, 2015*



3 Connecting the Unconnected

3.1. Defining the challenge

Globally, the most widely used means of accessing the Internet is through mobile networks and a mobile device. In a Business-As-Usual scenario Ericsson forecasts that by 2021, the world's mobile networks will constitute a technology base with the capability to provide Internet access to 7.2 billion people, or 92 percent of the global population. The rapid uptake and evolution of mobile technology as well as the declining cost of smartphones, particularly in developing countries, are expected to be the key drivers of this dramatic increase in access to the Internet.

Today almost half of the world population lacks access to the Internet, with people in developing countries representing an overwhelming majority of the unconnected. Access to the Internet is a fundamental enabler for improving quality of life and a critical success factors in realizing the SDGs.

At the same time, the estimated number of people who actually have Internet access is significantly lower. By 2021, 2.5 billion people are expected to remain unconnected despite the availability of technology, according to Ericsson's forecasts (Fig 3.1). Efforts to further accelerate this development and connect the unconnected must primarily focus on improving affordability and raising awareness, while leveraging the momentum and scale already achieved in the evolution of mobile technology.

Today 4.9 billion people are subscribers of mobile services with slightly more than 50 percent connected over a 3G or 4G network using either a smart phone or a device with mobile Internet features.[30] The remaining mobile subscribers are currently connected to 2G networks or using a 2G device. Although 2G provides significant value to everyday life, including some very basic data services, it is not reasonable to consider 2G service as access to Internet in the same way that 3G, 4G and future mobile technology generations are considered to provide Internet access. By 2021 Ericsson forecasts that more than 6 billion people will be subscribers of mobile services with the share 3G/4G/5G users sharply increasing to 86 percent, with only 14 percent of the world's mobile users connected via 2G. In other words, by 2021, 2.7 billion more people will become connected to the Internet over mobile networks compared with today.

Ericsson's mobile-based Internet access forecasts compared with estimates from other sources such as the ITU or the World Bank show slight differences. Typically, the ITU and the World Bank report a somewhat higher number of Internet users. This mainly relates to the role of fixed Internet access. Certainly, fixed Internet access plays an important role in boosting Internet benefits and is critical for achieving ICT's full potential of across society. However, in a more focused analysis of the challenge of providing Internet to all, fixed access plays a very limited role, mainly due to two factors. Firstly, in

markets with any substantial fixed access penetration, the mobile penetration is always well above 100 percent. In other words, it can be expected that any fixed Internet user is also a mobile Internet user. Basing the forecast on mobile Internet captures the development with high accuracy. Secondly, in markets where access to Internet through Internet cafes and other shared forms where Internet services play a role, it is important to consider the difference in benefits between a personal "always-available" access compared with an irregular service with a clear limitation in time and place. This analysis is further supported by the continued rapid uptake of mobile services.

An Internet connection forecast based on Ericsson Mobility Report data yields the following predictions within the 2015 -2021 time horizon:

- People connected to Internet through a 3G, 4G or 5G device increases from 2.6 billion to 5.3 billion.
- People connected to the mobile network with a 2G device (i.e., basic communication services but no Internet access) decreases with continued technology momentum from today's 2.4 billion to 0.8 billion.
- The number of people without any mobile device declines from 2.3 billion to 1.7 billion.

Out of the 2.3 billion that do not have a 2G device and lack connection to Internet in 2015, 300 million live in areas with 3G coverage. From a technology standpoint, this population has the possibility to connect to the Internet. By 2021 the population that lacks access to a 2G device and an Internet connection drops to 1.7 billion while the number of people with the potential to be connected is predicted to rise to 1.1 billion. That leaves some 600 million people, of which 300 million lack access to the Internet and the other half live in areas with only 2G coverage (Fig 3.2).

3.2. A rapidly changing picture

The unprecedented diffusion of ICT, as discussed in the Introduction, is paving the way to dramatically alter this situation. By 2021, around 95 percent of the world population will be covered by mobile networks (2G and beyond). 'Population covered' means that a person lives within the reach of a radio signal for a specific technology, while a subscription enables them to 'use' this technology. The rapid uptake of mobile technology, and the declining cost of smartphones, particularly in developing countries, is changing that picture. In sub-Saharan Africa, for example, mobile penetration was just above 50 percent five years ago: today it is at 80 percent, and by 2021 it is expected to reach 100 percent in the region.[31]

Ericsson's own calculations show that in a Business-As-Usual scenario, 2.7 billion more people will be connected by 2021, driven by demand for Internet access as well as the increasing diffusion of smartphones. The industry focus on global standards and interoperability has also led to dramatic economies of scale, while falling handset prices that also contributed to improved affordability and accessibility.

Figure 3.2. Snapshot of unconnected population globally, 2015, and projections for 2021

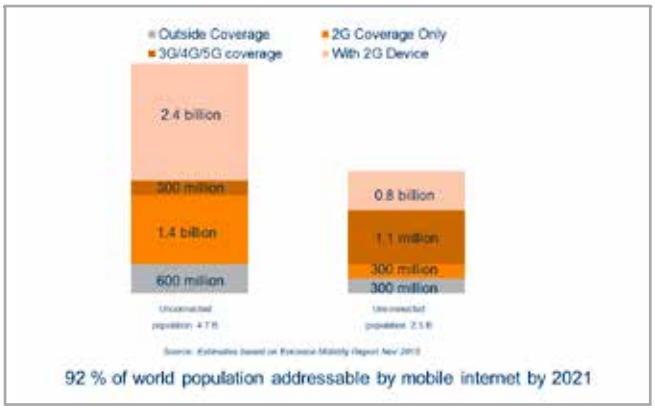


Figure 3.1. The number of unconnected globally

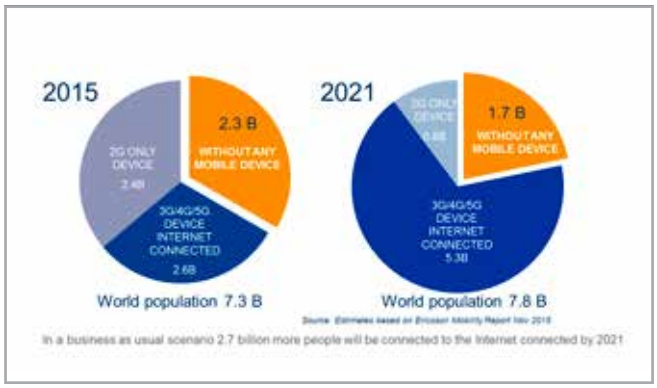
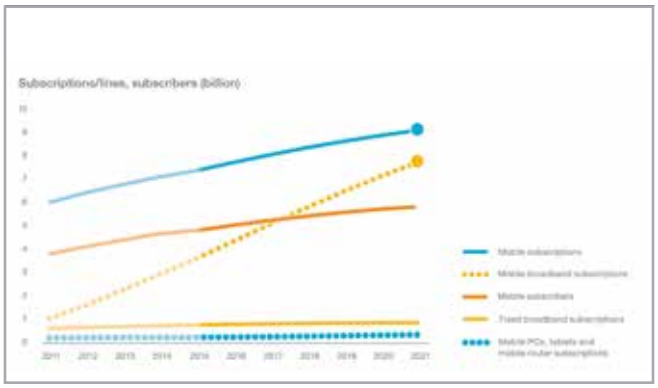


Figure 3.3. Subscription growth, mobile broadband



Although by late 2015, some 600 million people worldwide remained outside coverage, that figure is expected to drop to 300 million by 2021.[32] Of the unconnected by 2021, we know that:

- 2 of 3 live in rural areas
- 2 of 3 are above the age of 25
- 1 of 2 cannot afford a 3G connection
- 1 of 3 are illiterate
- A significant share are displaced populations[33]
- Many are unaware of or hesitant to use the Internet.

In addition to absence of network access, other key factors for the unconnected population include lack of understanding of the Internet as a concept and how it can help improve quality of life, as well as poor digital literacy skills. Gaps in enabling policy frameworks also play a part.

3.3. Tackling the chief barriers

Three main barriers must be overcome to bring everyone into the Networked Society:

- Affordability: cost of access, including devices.
- Usage: demand stimulation including local content and ICT skills.
- Infrastructure: technology deployment, spectrum, and viable business models

The following in particular are priority areas for action:

- Push the boundaries of mobile Internet, for instance, through industry 3G standardization (3GPP), extending existing business models and creating new business models (See Case 3.1) addressing urban and rural areas.[34]
- Secure and leverage other infrastructure such as roads, power, etc.
- Improve spectrum regulation
- Explore new types of public-private partnership.

On the technology front, incumbent technology vendors and new market entrants alike are advancing innovative technological solutions aimed at bridging the digital divide. Upgrading more common 2G networks to 4G LTE radios to provide widespread broadband connectivity requires viable business models or new types of partnership to enable the required investment.

The 4G networks could be an effective framework for expanding Internet access to many more millions of people. This approach leverages existing global investment in passive infrastructure such as network towers, as well as backhaul connectivity. It also deploys proven business models that include large chains of support stores built by operators that new users can access for help.

4G LTE enjoys a strong, robust ecosystem of devices and services. There are currently 480 LTE networks in 157 countries.[35] Because it is built on a global standard, it will be able to support and assimilate innovative technologies over the long run.

Some technology solutions are more experimental than others, and have yet to find acceptance among policymakers and regulators, including unmanned solar-powered aircraft[36] or high-altitude self-guided balloons capable of flying in the stratosphere,[37] and equipped with Internet-carrying transceivers, as a means of enabling and enhancing Internet connectivity for those in remote areas. While innovative ideas are welcome and necessary, any new technology faces the same policy scrutiny and business model challenges as existing and well-proven forms of reaching the unconnected.

3.4. Providing an enabling policy framework

Improving regulatory certainty and making harmonized spectrum available in a planned and timely manner is a priority for policymakers and regulators. Harmonized spectrum[38] helps to build economies of scale (based on a mass market), facilitates cross-border coordination between countries, ensures global roaming is achieved, provides interoperability, choice and convenience and guarantees efficient use of spectrum even in border areas, as well as providing long-term investment assurance for infrastructure and service providers and network operators.

One important area of concern remains the cost of spectrum, which in many countries is quite high. If operators are forced to pay high spectrum costs upfront, they may be too strapped for cash to build networks quickly. One alternative source of revenue that national administrations could consider is the increased tax revenue that ensues from greater commercial activity following deployment of high-end networks. Through licensed spectrum regulations, sector regulators have a lever to direct the market by attaching policy conditions and obligations such as specific geographical or population coverage. This is a means for governments to support bringing the benefits of ICT to more remote populations and marginalized groups. This is also where public-private partnerships can step in to address the inequity implicit in the lack of connectivity for many at the base of the economic pyramid, mostly in developing economies. This enormous challenge is prompting several political and economic actors—from government to industry, multilateral institutions to NGOs—to initiate programs to bridge the digital divide.

The Global Connect initiative of the US Department of State, formally launched in September 2015, is a case in point.[39] The initiative seeks to bring 1.5 billion people who lack Internet access online by 2020. It aims to bring governments and stakeholders together to explore ways to bridge the digital divide through country-specific strategies that create enabling environments, and spur connectivity and entrepreneurship, cross-border information flows and open and competitive marketplaces.

Many countries have also started developing their own national broadband plans and integrating ICT into national, urban and rural planning processes, with the aim of fostering inclusive growth that connects the unconnected in their respective societies.

3.5. Conclusion & Recommendations

By 2021, Ericsson predicts that 2.7 billion more people will become connected to the Internet over mobile networks compared with today. The population not using mobile services is predicted to be 1.7 billion. Of these, 1.1 billion live in areas where mobile Internet technology is in place. The challenge in reaching the unconnected rests more crucially on affordability, literacy and relevant services than the availability of technology.

An additional 300 million people live in areas where only 2G networks are in place; with only a marginal upgrade cost in technology, this population could benefit from the same opportunities as the 1.1 billion. The remaining 300 million unconnected people globally require technology to be extended into new areas in order to connect.

No doubt the most cost-effective and fastest way to tackle this challenge is to leverage mobile communication networks as the world's most widely deployed technology. Proactive and cross-sector society and business actions can speed up this development so that the benefits of connectivity extend to the world's poorest and most remote human settlements.

There are a number of steps that can be taken to address affordability and usage for the last mile:

- Develop cost/benefit-based business models targeting urban and rural areas
- Nurture eco-systems for local apps and content
- Prioritize development of ICT literacy and skills

Universal connectivity requires some public intervention, as market forces are not sufficient in the near-term. Universal Service Funds[40] which are a common feature of the mobile industry across most countries, are one example that could be utilized to subsidize the cost of upgrades and proactive regulation could ensure deployment in more challenging areas. A second possibility is to explore public-private partnerships with multilateral development banks, global aid agencies or private foundations underwriting key mobile broadband deployment projects, with various mechanisms for return on investment in order to create sustainable business models over time. A third option is to explore new business models that leverage extensive investments in mobile infrastructure, (Case 3.1). With commitment and collaboration, the last mile of connecting the unconnected can be bridged.

Case 3.1: Providing connectivity as a service in Benin*

Despite the rapid growth in mobile communications, commercially viable business models are still lacking in many rural areas. In Benin, Africa, Ericsson is implementing a solution called Managed Rural Coverage whereby operators can provide mobile coverage for a set period according to service level agreements and defined key performance indicators. Access is provided via low-power consumption Ericsson radio base stations running on solar energy to avoid the high costs and emissions associated with diesel generators. Together with mobile operator MTN the solution was deployed in 2015 to parts of central and northern Benin where there was no coverage previously, in essence providing connectivity as a service. The five-year contract covers 50 sites.

Managed Rural Coverage represents a new business model that makes it possible provide mobile coverage to areas most in need, such as remote areas of Benin where people have to survive on less than two dollars a day. With mobile connectivity, the people of Benin will be able to beneft from increased access to information and services that support health, education and small businesses.

* Ericsson Sustainability and CR Report 2015, http://www.ericsson.com/thecompany/sustainability-corporateresponsibility

4 Digital Identity and the Sustainable Development Goals

4.1 Introduction

In order to measure progress towards the achievement of the SDGs, comprehensive and accurate monitoring of how citizens are being accounted for across the 17 targets is critical. The challenge is that an estimated 1.5 billion people lack proof of identification, and are 'missing' from government registries.

A number of leading global institutions have highlighted that identification underpins many of the SDGs and is a prerequisite for success. Without proof of identification, a citizen's right to vote, open a bank account, go to school or access essential health services such as vaccinations can be prohibitively difficult. Achieving gender equality, good governance, social participation and the protection of rights is equally challenging. Additionally, there is a risk that "what is not counted, doesn't count" and the ability to measure the impact and outcomes of the SDGs overall could be compromised.

SDG target 16.9 seeks to address this by setting a target to: "By 2030, provide legal identity for all, including birth registration " and sets a high bar for the international community to strive for. Achieving this, however, will require new approaches, partnerships and technologies. Digital identity offers the potential to leapfrog from analogue ID infrastructures and scale access to, and participation in, the digital economy. Policy makers, private and public sector actors will need innovative strategies to overcome barriers and deliver on this opportunity and address issues of trust, privacy, and data management, for example.

4.2 The Identification Gap and the SDGs

Many of us rely on some form of official identification in order to navigate through daily life. From opening a bank account, accessing services from the government, making online payments, or boarding a plane—the ability to prove who we are can often be taken for granted. However, for the nearly 1.5 billion people globally whom the World Bank estimates do not have proof of official identity, the risk of not being accounted for is heightened.[41] Proof of identity has long been a problem for the poor, with low levels of birth registration particularly in Africa and Asia hindering access to fundamental services such as education and healthcare. The ID gap also disproportionately impacts women, compounding the challenge of asserting property rights, and gaining access to financial services or subsidies, for example. The geopolitical concentration of this issue in low and middle income countries underlines the importance of developing new means of enabling access to official identification for those who do not currently have it.

A barrier for government interventions

For governments, low levels of birth and death registration and a comprehensive identity system means that it is harder to target and monitor development interventions, allocate budget and ensure that the most vulnerable are not excluded, for example from targeted social protection programs, vaccination campaigns or financial inclusion schemes. Additionally, UNHCR estimates that there are 10 million stateless people globally, who, without a nationality, have no legal identity or status and are therefore denied their most basic human rights.[42]

If policy-makers and development actors don't know who the poor are, or where they live, development interventions will not be able to reach the intended beneficiaries, leading to leakages and inefficiencies.

Mobile operators have identified this challenge and have played an active role in providing innovative solutions across the identification lifecycle, from supporting enrollment through enabling mobile birth registration, to offering innovative authentication solutions.

A complex challenge

There are a number of complex factors that have contributed to the identification gap. Some of the most commonly cited challenges include:

- Logistical challenges (covering rural and remote areas, travelling to registration centers);
- Efficiency challenges (e.g. with paper-based systems);
- Social and cultural factors (poor awareness of the value of identification documents and need to stimulate demand);
- Governance issues (trust, oversight and political leadership);
- Cost and sustainability (investing in the architecture and capacity required to deliver a comprehensive ID system); and
- Technical (integrating existing systems, identifying the best technology solutions for value, coverage and robustness).
- Methodological (systems are built with privacy at the fore, ensuring that personal data of citizens is protected, and that rights to privacy are respected).

Despite these challenges, it is clear that identification is a key enabler for citizens to participate in social, economic and political life throughout the course of their lives. It is partially for this reason that the SDGs have highlighted the identification gap, and rallied the global community around a goal of universal legal ID coverage by 2030 as a core component of promoting peace, justice and strong institutions.[43]

Identification eases path to SDGs

Leading think tanks such as the Centre for Global Development and the World Bank's Initiative ID4D suggest that identification is core to achieving at least 10 of the SDGs in the following areas:

- Social protection, including for the most vulnerable.
- Assistance in dealing with shocks and disasters.
- Equal rights to economic resources, including property and finance.
- Empowerment of women.
- Improvements in maternal and child health.
- Coverage by vaccines and similar treatments.
- Improving energy efficiency and eliminating harmful energy subsidies.
- Child protection, including the ending of harmful child labor.
- Reducing remittance costs.
- Reducing corruption, fighting crime and terrorism and strengthening and improving the equity of fiscal policy.

4.3 The current state of digital identity

The Centre for Global Development estimates that as of 2013, there were approximately 230 digital identity initiatives in 80 developing countries. Figure 4.1 (p. 31) shows different types of digital ID systems across countries. Identification systems can be broadly grouped into two categories: Foundational (ID systems "which provide general identification covering the entire population (and can include civil registries and unique national IDs) and Functional which cover population subsets and are introduced in response to a demand for a particular service or transaction (such as voter registration[44])."

While there is no single approach to digital identity, fragmentation between functional and foundational identity systems and duplication have grown. Different models have been developed, depending on current levels of ID coverage, political and cultural context, the needs of a particular country and existing analogue and digital identity architecture. A growing number of successes stories are emerging, highlighting the possibilities for citizens, governments and private sector actors if these initiatives are designed with scale and sustainability in mind.

For example, the impressive rollout of Aadhaar, India's unique digital identification program, which has now enrolled its one-billionth person, highlights the potential for digital identity to reduce corruption and drive inclusion and

Without proof of identification, a citizen's right to vote, open a bank account or access essential health services may prove prohibitively difficult.

efficiency. The World Bank estimates that India has saved one billion dollars USD through linking Aadhaar numbers to its government payment programs, reducing duplicate and ghost payments, improving financial planning and management and increasing transparency.[45]

In Estonia, citizens are able to use mobile and e-IDs to register a business, declare their taxes and digitally sign documents.[46]

In countries such as Pakistan, the national identification body, NADRA has enrolled upwards of 98 million people through biometric technologies and has linked this to improving targeted development programs for example for women and for disaster-affected populations.[47] In a number of countries such as Tanzania, Uganda and Pakistan, mobile network operators (MNOs) are partnering with government and organizations such as UNICEF to accelerate birth registration through digital technology.

While there may not be a one-size fits all approach for expanding identification and integrating ICT to deliver robust and accessible digital identity systems, there are some common considerations and barriers that must be overcome to unlock future opportunities. These considerations will ensure that digital ID systems are developed in a way that supports development outcomes.

4.4 Issues and Challenges

ICT offers an opportunity to bypass traditional approaches to identity provision and management. Digital identity solutions, through their potential for scale and reach, can lead to improved efficiencies and accelerated economic, political and social inclusion. However, positive outcomes are not guaranteed, and there are a number of considerations and challenges that should be addressed and mitigated by different actors involved in design, funding and implementation of these initiatives:[48]

- **Inclusivity**—ensuring that digital ID initiatives are accessible, affordable and do not exacerbate exclusion.
- **Adoption**—developing solutions that are fit for purpose, are designed with the end-user in mind, and that consider the levers for take-up by building awareness, and demonstrating the value of digital identity.
- **Privacy and trust**—ensuring data privacy and security and building trust in digital identity solutions with different stakeholders is essential to developing healthy digital identity eco-systems.
- **Policy and regulation**—ensuring that the policy environment is clear, and that there are robust frameworks to encourage investment and build trust.
- **Leadership**—political leadership, vision and a long-term commitment are required to build digital identity systems that can foster development outcomes.
- **Interoperability**—identifying standards, agreements and models for interoperability will be important for reducing fragmentation and building a seamless digital ID ecosystem.
- **Coordination**—alignment among the development community, private sector, governments and other actors is essential to reduce duplication and ensure that citizens can benefit from the rollout of digital identity solutions.

It is clear that proof of identity is becoming increasingly central to achieving development outcomes and enabling participation in the digital societies of the future, and that ICT offers a transformative opportunity to increase efficiency, coverage and impact. New models of public-private sector co-operation and coordination by global institutions and the donor community will be needed, as will alignment and willingness between different stakeholders to address the barriers, in order to realize the transformative opportunity of digital identity.

Case 4.1: Digital ID aids financial inclusion

The GSMA estimates that there are now over 411 million registered mobile money accounts globally.[49] Digital financial services are accelerating financial inclusion, particularly for the poor, leading to promising gains in social and economic development. However, proof of ID is required to meet "know your customer" requirements for opening bank accounts and meeting financial regulation requirements both on- and off-line. Approximately 375 million people globally have cited not having access to financial services because of a lack of recognized ID.[50] In countries such as Pakistan, harmonizing KYC (Know Your Customer) requirements and linking targeted programs such as the Benazir Income Support Programme with national digital identity infrastructure are laying the foundations to increase financial inclusion.[51]

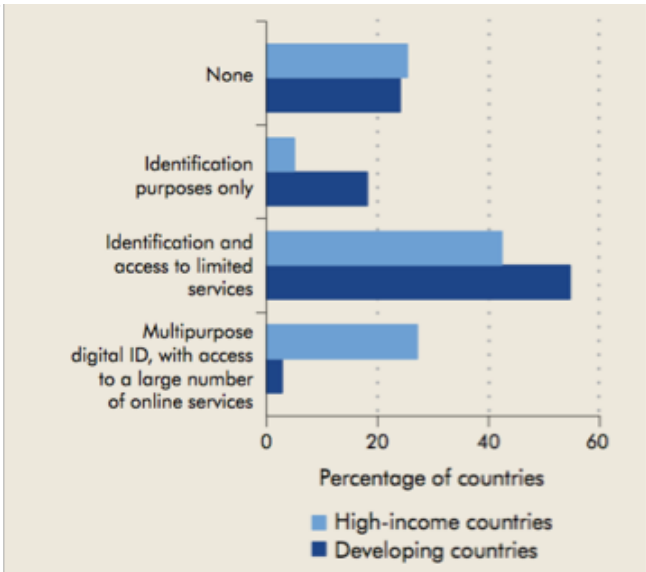
Case 4.2: Mobile-enabled birth registration

Birth registration is identified as a critical stepping-stone in ensuring provision of official identity and protecting the rights of the child. International law specifies that every child is entitled to birth registration.[52] However, UNICEF estimates that more than 230 million children under the age of 5 have not been registered globally. In Tanzania and Pakistan, Mobile operators are leveraging the scale and reach of their networks to enable and accelerate birth registration through partnerships with national authorities and organizations like UNICEF.[53] In the pilot region of Tanzania, Tigo, RITA and UNICEF have, through their SMS platform, raised registration rates from 8 to 45 percent and are targeting 1 million births to be registered by the end of 2016.[54]

Case 4.3: Meeting the ID challenge for refugees

The UN Refugee Agency, UNHCR, has integrated ICT solutions to address the challenge of identifying the growing and changing population of refugees and forcibly displaced people under its protection. Through its newly developed Biometric Identity Management System (BIMS), UNCHR is able to provide a unique identity to beneficiaries without documentation with the aim of assuring correct delivery of entitled services and benefits, secure identity management and improved data and monitoring to inform long-term and permanent solutions.[55] Global rollout of BIMS commenced in 2015 with promising results. For example, in Chad, UNHCR is able to enroll 2,500 people per day, linking those enrolled and verified with ration cards and other services.[56]

Figure 4.1 Different types of digital ID schemes across countries



Source: World Bank ID4D database (various years). Data at http://bit.do/WDR2016-FigS4_1.

5 ICT & Financial Inclusion

Embracing the Goals

Financial inclusion is an important driver for attaining the SDGs. Universal financial access can reduce poverty (SDG 1) through employment and income-generating business opportunities (SDG 8), including for small and medium enterprises (SDG 9). Availability of financial services such as credit, savings and insurance can provide greater security for people during crises due to natural disasters, financial crisis or political turmoil (SDG 10). With higher income, families can invest in education (SDG 4) and health (SDG 3) and, end hunger, achieve food security and improved nutrition (SDG 2) and promote sustainable agriculture, as mobile payments can enable access to water and energy and better crop yields through connected agriculture (SDG 15). Not least, financial inclusion can help empower women (SDG 5).

SDG target 8.10 calls specifically for the capacity of domestic financial institutions to be strengthened to encourage and expand access to banking, insurance and financial services for all. SDG target 9.3 advocates greater access of small-scale industrial and other enterprises to financial services—especially in developing countries—including affordable credit and integration into value chains and markets. Finally, universal financial access will help in delivering SDG 10, which calls for reducing inequalities within and between countries. Even if several of these SDGs do not explicitly call for the role of mobile money or digital financial innovation, it will be fundamental to their achievement.

Facing the Challenge

Some 2 billion people around the world do not use formal financial services and over half of adults in the poorest households remain unbanked. More than half of adults in the poorest 40 percent of households in developing countries were still without bank accounts[57] in 2014—primarily women. Women's participation in economically productive activities is currently constrained by both limited access to finance and lack of ICT skills.

Limited financial infrastructure is a major obstacle for many countries. In regions where traditional financial service points such as bank branches and automated teller machines (ATMs) are lacking, the challenge of finding cost-effective ways to make financial services available to citizens is a significant barrier to inclusion.

The main barriers to having an account in a financial or micro-financial institution are high service costs (55%), lack of money (54%), lack of confidence in financial institutions (37%), distance from financial institution (23.7%) and not having the documentation required (15.7%). ICT, and particularly mobile money, is helping to overcome these obstacles on the path to financial inclusion.

5.1. Introduction

In a relatively short time, the link between ICT and financial inclusion has become clear: ICT offers a cost-effective way to overcome the existing lack of banking infrastructure faced by many countries. It can be rapidly scaled, offers significant efficiency gains, and entails low barriers to entry for individual users.

Mobile money is available in 85 percent of countries where the vast majority of the population lacks access to a formal financial institution.

Source: GSMA, State of the Industry Mobile Money Report 2015

The vision is that connectivity enables a world where financial services are accessible to all and interconnected to each other, where sending money is as easy and affordable as sending an SMS, and where any device becomes a commercial device.

At its most basic level, mobile money is the provision of financial services through a mobile device. It covers a range of services including payments (person-to-person), finance (such as insurance products), and banking, and is supported by a network of agents who receive a small commission for turning cash into electronic value. More than a technology, mobile money comprises an ecosystem that includes the finance and ICT industry, mobile network operators and other stakeholders—not least government, which must create the appropriate regulatory environment.

Huge gaps persist between countries when they are ranked based on bank account ownership (Figure 5.1). The top countries are all high-income countries with better access to mobile and Internet services. In these countries almost everyone has access to the Internet (on average 91 per 100 people) and mobile phones (on average 120 subscriptions per 100 people).[58] In low-scoring countries, average Internet and mobile phone users per 100 people are 9 and 73 respectively, and only 2-12 percent of people aged 15 or above are able to access bank accounts. The relatively high penetration of mobile phone subscriptions relative to bank account owners in these countries shows there is great potential for mobile banking services to help close the gap.

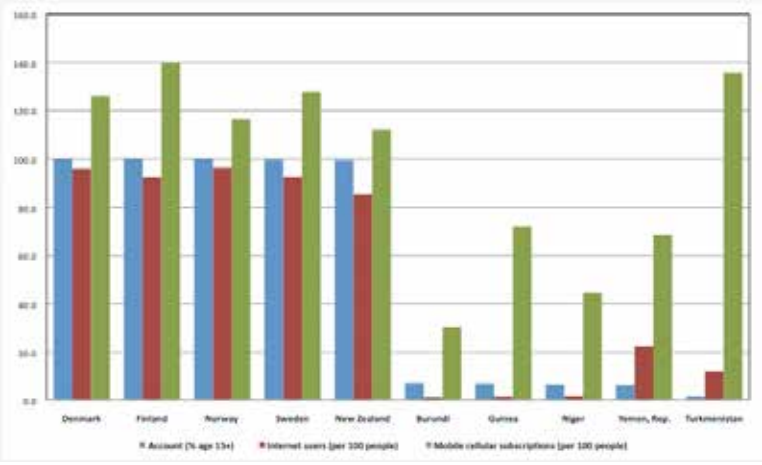
Rapid uptake and evolution of ICT in recent years has fuelled innovation in financial services offering considerable potential to drive achievement of development goals around financial inclusion. Today there are a number of successful applications from around the world, many of which can be replicated and scaled. Mobile money is most widespread in low-income economies, compared to lower-middle-income and upper-middle-income economies. With 271 live services in 93 countries and 64 percent of the developing world covered, mobile money continues to deepen financial inclusion and is currently reaching more than 411 million people globally.

Some 700 million adults worldwide became bank account holders between 2011 and 2014, yet 2 billion are still unbanked.

World Bank Global Findex Database, 2014

One of the greatest advantages of using ICT to deliver services is that access can be cost effectively scaled once the infrastructure is in place. This is particularly significant in the

Figure 5.1. Financial inclusion in select countries based on accounts, 2014



This graph shows the top five countries and lowest five countries in financial inclusion levels, based on bank accounts, according to the World Bank. Source: Global Findex 2014 and ITU.

context of achieving SDG target 1.4, which requires reaching a large number of poor and vulnerable people in the goal of reducing extreme poverty. SDG 1 aims to eradicate extreme poverty for all people everywhere by 2030, with extreme poverty currently measured by the World Bank as living on less than USD 1.25 a day. From 1990-2015 the rate of extreme poverty in developing countries fell from 43 percent to 14 percent in 2015 according to UN data, but the number of global poor remains high: at present, about 800 million people live in extreme poverty, and inequality within countries and across regions continues to be a major challenge.

Through Internet, broadband and mobile phone-based ICT infrastructure, people living in poverty gain the capability to improve their economic situation by accessing reliable financial services that can provide a vital safety net. From obtaining an account and conducting basic transactions such as money transfers and bill payments, users can move on to access more advanced financial services such as loans and insurance products (see Figure 5.4 on p. 37). The increased access to financial services that ICT enables can in turn encourage private investment, spurring job creation and economic growth for vulnerable target populations.

SDG target 1.4 sets out that by 2030 all men and women—particularly the poor and the vulnerable—should have equal rights to economic resources, as well as access to basic services, ownership, and control over land and other forms of property, inheritance, natural resources, appropriate new technology, and financial services including microfinance.

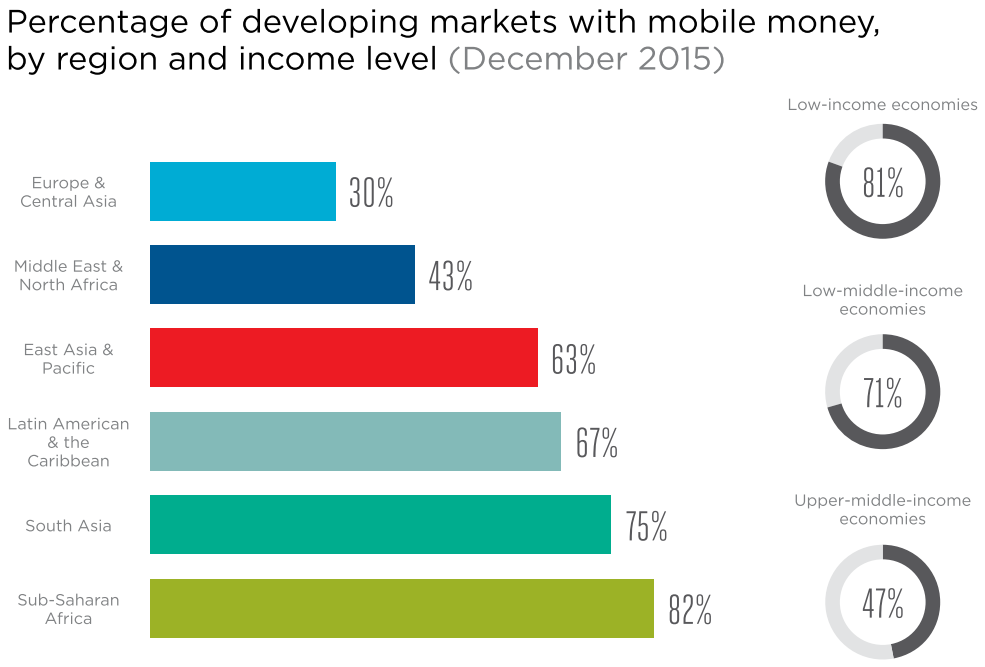
The importance of financial innovation for economic growth in Western countries cannot be understated. There is enormous potential for developing countries to leapfrog in this area based on new ICT technologies.

5.2 ICT in action: Banking the unbanked

Growing connectivity is spurring the growth of mobile services, particularly in developing countries (see Figure 5.2). As seen in Sub-Saharan Africa, mobile money accounts can drive financial inclusion. While just 1 percent of adults globally say they use a mobile money account and nothing else, in Sub-Saharan Africa, 12 percent of adults (64 million) have mobile money accounts (compared to just 2 percent worldwide); and 45 percent have only a mobile money account.[59] When it comes to meeting the enormous challenge of rolling out financial services to the unbanked by 2030, ICT can be a powerful accelerator.

As well as improving access, mobile—or branchless—banking also offers a number of quality and efficiency gains. It reduc-

Figure 5.2. Percentage of developing markets with mobile money, by region and income level (GSMA, Dec 2015)[60]



When it comes to meeting the enormous challenge of rolling out financial services to the unbanked by 2030, ICT can be a powerful accelerator.

es the time and cost required for people to travel to bank locations and wait in line, for instance to pay bills. Information flow and data collection through ICT can improve customer service by facilitating deposits and transfers, and helping banks make faster credit decisions. It also offers a means of providing financial services to those who would otherwise not be eligible for banking services due to low asset ownership.

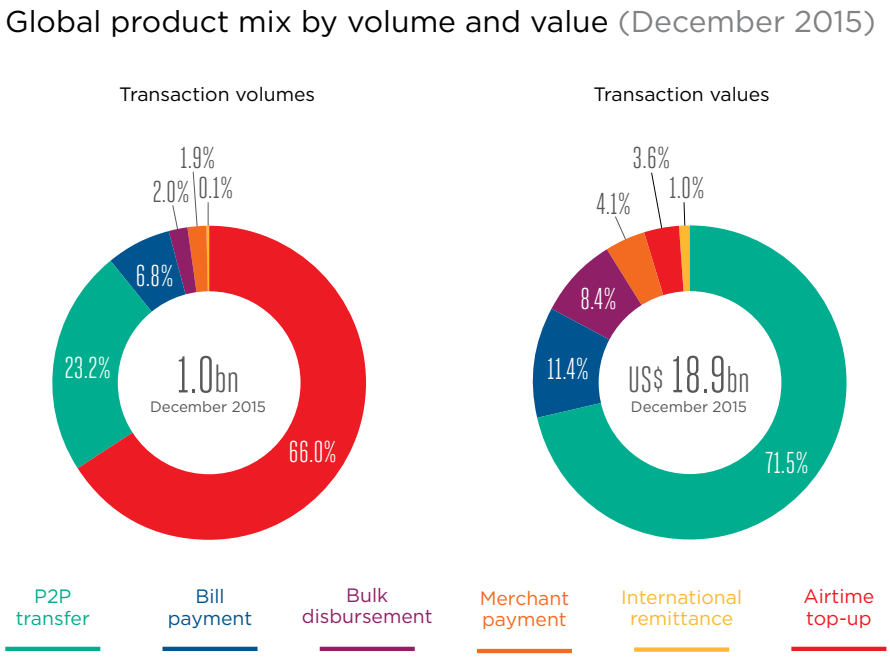
At a global level, mobile money remains dominated by narrow use cases (see Figure 5.3). In 2015, almost three-quarters of the total value of transactions were person-to-person (P2P) transfers. By volume, airtime top-ups accounted for two-thirds of all transactions processed in 2015.[61] Future expansion of mobile banking services, types of use cases and higher volume of mobile money will depend on the readiness of financial institutions to adopt the technology and to collaborate with mobile operators and other players in creating a single platform (as illustrated in Case 5.1, Modelo Perú).

There are a growing number of examples of mobile money initiatives that provide financial services to a vast population formerly without access to banking services. Mobile technology has enabled a platform for various types of mobile money and services (Figure 5.4.) such as mobile finance, mobile banking and mobile payment. As a result, people can send and receive money, save money, check their account balance, make payments for purchases, pay bills, perform bank transactions and get access to lower cost credit and insurance services. The reduction in use of cash has made such financial services more convenient, affordable, accessible, and attractive. It also has major advantages over cash by eliminating the risk of theft.

One of the pioneers of mobile money is M-Pesa. Launched in Kenya in 2007 through mobile operator Vodafone, it has become the country's largest service, counting over 15 million account holders. Now in 10 countries including Egypt, Fiji, India, Romania and Tanzania, M-Pesa has evolved from a simple mobile transfer service between individuals to a broader set of financial services allowing people to deposit savings, pay bills, or purchase health insurance.[63]

Although still in the early stages, a robust mobile financial ecosystem will help to ensure services become more relevant and useful to consumers, and sustainable over the long term. Four successful approaches are featured in the following cases: Modelo Perú's program Bim; EcoCash in Zimbabwe; EasyPaisa in Pakistan, and Orange Money, which serves multiple African countries.

Figure 5.3: Mobile money transactions by mix, volume (GSMA, 2015)[62]



Case 5.1: Modelo Perú is driving financial inclusion in Peru

In Peru, ASBANC, Peru's National Bank Association, has launched Modelo Perú, an initiative considered a model new financial eco-system. The aim is to accelerate the transition from cash to digital payments in order to reduce poverty and drive inclusive growth, in line with Peru's National Financial Inclusion Strategy launched in 2015, in which the government pledged that 75 percent of adults would have access to a transaction account by 2021.[64] With some 34 financial institutions and three mobile network operators sharing one mobile money platform, ASBANC wants to provide easy-to-use, secure, next-generation mobile financial services. The goal is to reach 2.1 million underserved Peruvians, about 7 percent of the total population, within five years, especially those without access to traditional banking services.

In 2015, Ericsson was selected as the partner to implement the technology platform and provide operational and business services. The program developed by the partners is called Bim (short for Billetera Movil, or Mobile Wallet).

Lessons learned

By working together, Modelo Perú has built a strong base to incentivize use. A shared brand, product offering, fee set, and transactions all contribute to a higher value proposition for the users. With a common national agent network, Bim users have tens of thousands of access points and merchants should soon come on board. The government gains a tool to disburse payments while businesses can transition from cash to digital payments. By developing a platform that works anywhere and for everyone, government and businesses can begin to lower costs and drive efficiencies—promoting the long-term shift from cash to digital payments. Once acceptance is fully developed, customer behavior is expected to change, too.

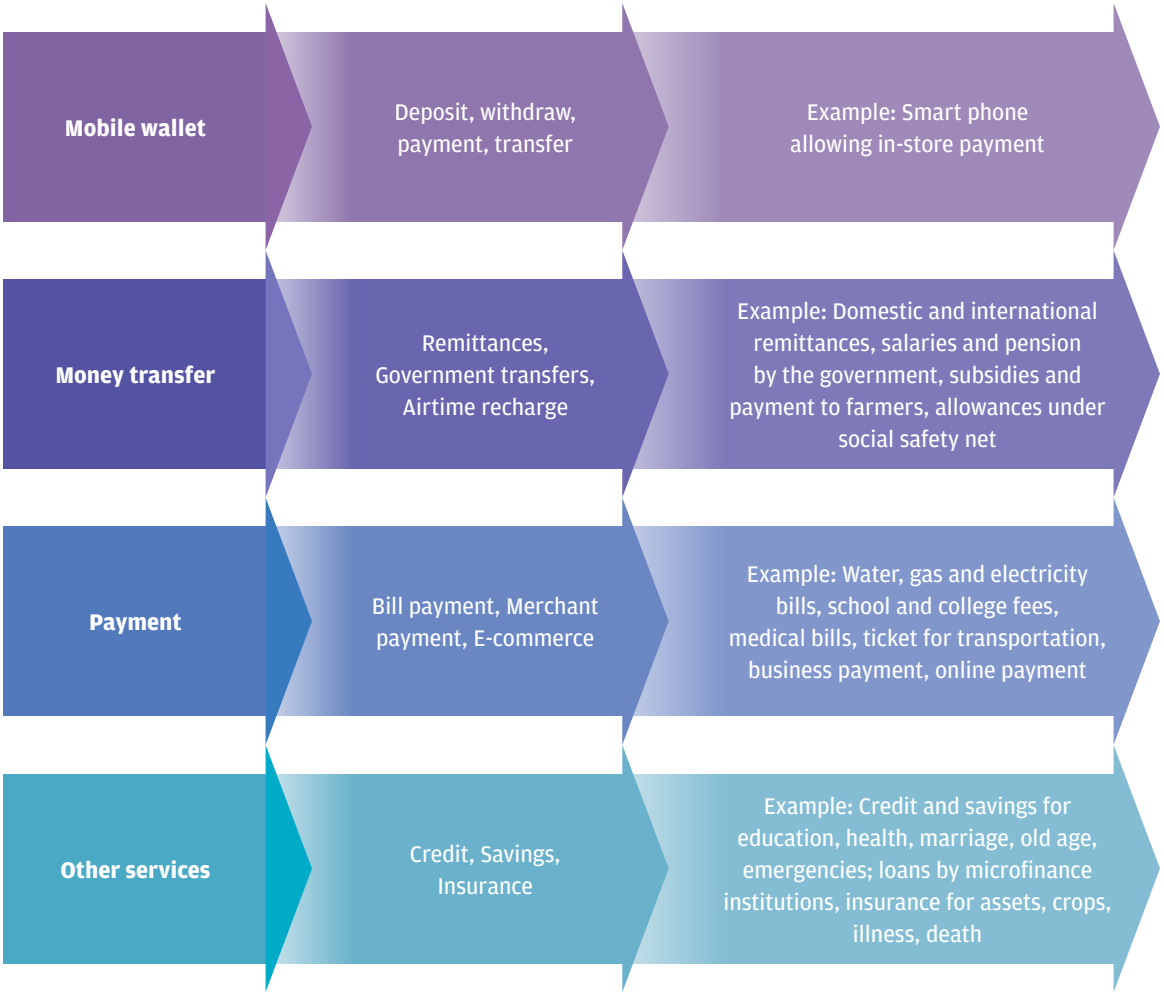
Why is "Modelo Perú" innovative?

As the world´s first interoperable, shared mobile payment platform targeting financial inclusion, the initiative is unique in several ways: 1) It was necessary for the partners to collaborate in order to have the opportunity to compete and generate profit. More than a technological innovation, partners see it as a new way of doing business. By working together, the institutions in Perú realized they had a better chance to reach the nearly 70 percent of Peru's population[65] that is unbanked. 2) All partners share a common technology platform, lowering the cost of design, customization and implementation. New features become available to all customers and providers at the same time, which enables a common product across providers.

3) All institutions share a common brand, "Bim", and thus all customers see and recognize the same brand. There is also a standard fee among providers which builds trust among customers to increase adoption of the service. 4) The regulatory environment enabled financial inclusion. In 2013, Peru approved e-money law no. 29985,[66] which regulates the basic features of electronic money as an instrument for financial inclusion. While the partners behind Modelo Perú are aware that regulation itself is not sufficient to create a market, this allowed different players in the eco-system to collaborate with clearly indentified roles.

Two months after the launch in Febuary 2016, Bim already had 85,000 registered users and 55,000 of them were making use of the services available to them as active users.

Figure 5.4. Range of ICT-linked Financial Services



Case 5.2: EcoCash paves the way for digital economy in Zimbabwe

In Zimbabwe, EcoCash is one of the most rapidly growing mobile money solutions in Africa. Just 18 months after the launch in 2011, some 2.3 million Zimbabweans had registered for EcoCash mobile money accounts, outnumbering all of Zimbabwe's traditional bank accounts combined,[67] and today that figure exceeds 3.5 million subscribers.[68] EcoCash is part of Econet Services, an independent company set up in 2012 by Zimbabwe's largest mobile network operator, Econet Wireless.[69] It enables customers to complete simple financial transactions on their mobile phones, such as sending money to loved ones, buying prepaid airtime for themselves or other Econet subscribers and paying for goods and services.

Lessons learned

EcoCash was able to fundamentally alter the financial landscape in Zimbabwe by starting with a simple use case that fills a basic consumer need: sending and receiving money. It also invested in a strong and committed network of agents to meet demand. With some 60 percent of the population having access to mobile phones and only 32 percent of the population owning bank accounts,[70] there is a robust foundation for the growth of the digital economy—and mobile money—in Zimbabwe.

Case 5.3: Orange is the color of mobile money across Africa

From cross-border remittances to payments to money transfers and financial services—including insurance products tailored to women—Orange Money is enabling greater financial inclusion across Africa. A service of Orange, one of the largest operators of mobile and Internet services in Europe and Africa, Orange Money has currently 17 million Orange Money users in 14 countries, representing more than 4.5 billion euros' worth of transactions in 2014.[71] From November to December 2014, the equivalent of 20 percent of the GDP of Mali passed through Orange Money. Financial services such as saving, insurance and micro-credit solutions are offered in partnership with banks and insurance companies.

In Mali, where insurance products are lacking, and fertility and maternal mortality rates are some of the highest in the world, Orange Money saw an opportunity to launch two new, intertwined savings and insurance products targeted at Malian women. Thanks to a GSMA Connected Women Innovation Fund grant, Orange joined forces with NSIA, a microinsurance company, the NGO Population Services International and PlaNet Guarantee, an insurance mediator, to launch a savings product (Sini Tonon) and an associated life/disability and maternal health insurance product (Tin Nogoya) on the Orange Money platform.

Lessons learned

Although still in early stages, Sini Tonon and Tin Nogoya are already delivering commercial and social benefits to Orange and its customers. Sini Tonon is encouraging customers[72] to save: 55 percent of women and 48 percent of men did not save before using Sini Tonon. Tin Nogoya is well positioned to foster first-time access to insurance, especially for women, who are less likely than men to be insured. 97 percent of female users have never been insured before and 98 percent of surveyed users want to continue saving to reach the threshold for insurance activation.

Case 5.4: In Pakistan, EasyPaisa[73] paves way for the unbanked

Launched in 2009 by Telenor Pakistan in collaboration with Tameer Microfinance Bank, Easypaisa is Pakistan's first and largest branchless banking solution and one of the largest mobile money deployments globally with more than 21 million active consumers. The initiative aims to greatly expand financial inclusion, as only 15 percent of Pakistan's population are reported to have a bank account. In May 2016 Easypaisa announced it is deploying Ericsson Wallet Platform to replace its existing platform. The partnership with Ericsson accelerates and increases the availability of mobile money services for the country's citizens, while positioning banks to succeed in an expanding mobile money ecosystem.

With a growing footprint of over 75,000 merchants in over 800 cities throughout the region including rural areas, Easypaisa is providing numerous employment opportunities, while enabling people to send and receive money from any Easypaisa shop in a secure, efficient and convenient way.

Lessons learned

Easypaisa's product portfolio includes bill payment, sending or receiving money, purchasing airtime, salary disbursements, giving donations, disbursing social cash transfers, insurance and savings. Anyone in Pakistan can use Easypaisa's money transfer service to send money from one city to another even if they don't own a Telenor connection. It enables those without bank accounts to send their monthly salaries back to family members in their home villages, or transfer tuition fees or personal funds to their children at faraway educational institutions. Frequent travelers who don't want to carry cash can use the service to send money to themselves for collection in another city. This kind of mobile banking improves safety, reduces the need for lengthy paperwork, and enables money transfer to be done outside normal business hours, eliminating the need to queue.

As part of its mission of empowering societies, Easypaisa is also collaborating with Nestlé Pakistan in providing financial access to thousands of Pakistani dairy farmers to make disbursement of milk collection payments swift, easy, and transparent.[74] Easypaisa has won numerous awards, including 'Best Mobile Money Service and 'Best Mobile Service for Women in Emerging Markets' at the GSMA awards 2014, as well as the Wall Street Journal's 'Financial Inclusion Challenge People's Choice Award' 2015. Recently it was nominated at the GSMA Awards as 'Best Mobile Money service for Women in Emerging Markets 2015 and 'Best Mobile Money service for Women in Emerging Markets' 2016.[75]

Case 5.5: In Sweden, banks unite behind Swish[76]

Efforts to develop Swish started as a collaboration between six of Sweden's largest banks: Danske Bank, Handelsbanken, Länsförsäkringar, Nordea, SEB and Swedbank and the savings banks. In December 2012 they launched Swish, a mobile payment solution between private individuals. In the past few years four other banks and financial institutions came on board, and the hope is that more banks will join. In 2014, Swish introduced the possibility for private customers to use Swish payments to affiliated companies, associations and organizations.Each bank is responsible for designing the offer, conditions and any contributions to their respective customers. The Swish brand and service is owned by Gets Wish AB, formed by the founding banks. Swish is now the paid service that most Swedes use and pay apps have emerged as the most common way to make a payment to a friend, particularly among those 16 to 29 years old, where seven in ten surveyed use the service. The "Swish effect" has seen use of cash decline markedly while credit card payments have increased.

5.3 Fostering enterprise productivity through e-commerce

SDG target 8.3 calls for development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage formalization and growth of micro, small and medium sized enterprises (SMEs) including through access to financial services. SDG Target 9.3 also calls for an increase in the access of small-scale industrial and other enterprises to financial services—including affordable credit—and better integration into value chains and markets.

Financial inclusion through e-commerce is a growing ICT application that can have positive impact on business. Global e-commerce is evolving fast, bringing new opportunities for SMEs and rural enterprise. Prohibitive service costs, high interest rates and too much of the profit going to middle men all currently discourage small entrepreneurs from approaching banks for capital to start and grow their businesses. ICT can address these barriers by helping to reduce service costs. Where the share of producers in both the local and global value chain remains low, ICT can increase access to market information and new markets. Higher product prices and a greater share of the value chain will make businesses more profitable and increase income per capita, helping to reduce poverty.

Online market places have created platforms for sellers, customer service, payment processing, and shipping, delivery and return processing. Affordable Internet mechanisms enabling payment for goods and services are an effective enabler for delivery of goods through online transactions. SMEs that are able to harness this technology can benefit from the opportunity to enter international markets, export their products and services and gain competitive advantage from reduced costs of production and service delivery.

Research on the impact of ICT on SMEs is limited, but studies indicate that linking SMEs to e-commerce to market their products is a powerful way to boost productivity. In Nigeria[77] ICT has been found to help SMEs make better decisions by speeding up analysis of large volumes of data. A study of 14 European countries has shown that for firms engaged in e-sales, labor productivity grew by 0.3 percentage points per year between 2003-2010.[78] The study also indicates that small enterprises engaged in online sales enjoy greater productivity, highlighting the importance of ICT-readiness and access to ICT-led financial services for SMEs. This indicates that industries with an increase in the proportion of firms selling through computer networks experienced a higher growth rate of labor productivity.[79]

But while large companies are generally well placed to reap productivity gains through ICT and e-commerce, small enterprises tend to lag behind, with SMEs in developing countries in particular facing a number of barriers. In addition to the high cost of telecommunications, micro and SMEs often lack the capacity to use ICT-led financial services due to poor communication infrastructure and lack of regulatory support, are hindered by the prevalence of obsolete technologies and prohibitive cost of installing new technology, and suffer from a lack of qualified staff and low digital literacy skills.[80]

Skills improvement and capacity-building are therefore preconditions for these businesses to access ICT-financial services. In developing countries where unemployment or under-employment of youth and women are a growing problem, expansion of micro and small business can create vital employment opportunities needed to eradicate poverty. By addressing low digital literacy levels and promoting SME access to ICT-led financial services, policymakers can provide a much-needed boost to the small business development-related SDGs.

Case 5.6: Mobile commerce, grassroots to government-driven

To close the gap between rural and urban regions, in 2001 the Korean government established a mobile commerce platform called INVIL (Information Network Village). With close collaboration between the government, INVIL telecenter operators and rural businesses, the experience has been positive, product marketing and sales have risen and rural e-commerce is thriving.[81]

Lessons learned

Intensive government support has been key to the nationwide success of the platform. Success factors have included providing training opportunities, branding and marketing assistance and encouraging the private sector to develop an up-to-date e-commerce portal with links to other online portals around the country. In addition, reliable payment and delivery systems, efficient logistics and high online shopping activity by consumers have also played a key role.

In China, local government and small business owners in rural villages have successfully leveraged the country's leading mobile commerce websites to sell their local products via the Internet. For example, since 2006, the furniture and manufacturing industry has burgeoned due to the development of online retailing, and in one province, entrepreneurs were trained in mobile commerce to meet the growing demand for agricultural products via e-commerce. The local government assisted, upgrading transport infrastructure to allow for ease of delivery of the province's products.[82]

Significant growth potential

In both cases, entrepreneurs leveraged mobile commerce to build national and international market demand for goods produced from abundant local resources. As the Chinese e-commerce market is the largest in the world, demand for these rural products is healthy, with significant further growth potential. Leveraging mobile commerce has also created a wider positive feedback loop for these communities, through the rise of supporting facilities such as delivery services, logistical backing, upstream crop revitalization and processing and packaging industries.

Although the Chinese government was not directly involved in this process, it provided indirect support through improved infrastructure such as roads and highways, broadband Internet facilities and by enabling the necessary certifications.

5.4 Strengthening domestic institutions through digital infrastructure

SDG target 8.10 calls for strengthening the capacity of domestic financial institutions to encourage and to expand access to banking, insurance and financial services for all. Increased investment in financial infrastructure and in the capacity building of individuals and enterprises is needed to achieve this target. Once this target is achieved, it is expected that financial infrastructure such as collateral registries, credit rating, credit bureau and payment and settlement systems will be in place, which along with greater digital literacy, will enable market growth for financial services.

Some leading banks are recognizing the potential of ICT to help strengthen economic development and financial inclusion. In 2016, the African Export-Import Bank (Afreximbank) has adopted a new Intra-African Trade Strategy aimed at driving industrialization across Africa and increasing intra-African trade by at least 50 percent in the next five years. The strategy will involve expanding existing trading activities within Africa's regional economic communities, integrating informal trade into formal frameworks, reducing trade barriers and minimizing the foreign exchange costs of intra-African trade. About 40 percent of intra-African trade is done in the informal sector, revealing institutional gaps.[83]

To this end, the bank is exploring the option of introducing a mobile payment platform to support intra-African trade and payments.[84] The bank estimates that this would essentially bring in around USD 50 billion of informal regional trade that takes place on the continent into the formal sector, with attendant benefits to governments, businesses and trade financiers

Making remittances more affordable and accessible

In 2013, more than 230 million people lived outside their countries of birth and more than 700 million migrated domestically.[85] These figures from the United Nations[86] highlight a real need for lower-cost transfers of money, or remittances, from developed to emerging markets. Mobile money can help by lowering costs. The World Bank estimates that remittances totaled USD 582 billion in 2014, USD 435 billion of which went to developing countries, involving some 232 million migrants.[87] Yet the cost of sending remittances is still very high in some countries, particularly poor countries. For instance, from South Africa to Zambia, the average cost was USD 19.35.

International remittances are a major and stable source of income for people in many developing markets. One in seven Africans (120 million) receives remittances from friends and family abroad, representing USD 60 billion and as much as a third of total GDP[88] in some African markets.[89] Yet Africans pay the highest transaction fees in the world.[90]

Cross-border mobile money remittance was the fastest-growing mobile money product for the second year in a row, with 29 initiatives connecting 19 countries. Cross-border transaction volumes grew by 51.8 percent and the median cost of sending USD 100 via mobile money reduced by half to USD 2.00.[91]

With mobile money, on average, users pay around 2 percent of the transaction value. This is substantially lower than the fees charged by formal MTOs or informal remittance providers in these markets, which typically exceed 5 percent.[92] With high transaction costs cutting into remittances, a lifeline for millions of Africans, lowering these costs can advance financial inclusion.

5.5 Empowering women through financial participation

By 2030, one billion women currently excluded from financial services can be connected through technology.

SDG target 5.b aims to enhance the use of enabling technology, in particular information and communications technology (ICT), to promote the empowerment of women. Women are often the household CFO (Chief Financial Officers), managing multiple financial streams within the family, including income, expenses and savings—yet this is typically cash only.[93] ICT is a means to reach vulnerable groups like underprivileged women currently excluded from financial services and help fulfill the shared global commitment to ensure that no-one is left behind.

Universal financial access will help women save their income, access credit and benefit from a wide range other financial services like insurance. As a result they will gain greater control over their money to make investment and spending decisions that can improve their standard of living. Historically, women's spending has been primarily directed towards the welfare of their families, so female financial inclusion is likely to have a positive impact on the welfare of entire communities.

Extensive research on the role of ICT for women's empowerment indicates that women can benefit immensely from ICT-led financial services.[94] ICT helps women to access the capital needed to establish and grow their businesses. As a result, by 2030, the share of women-owned business entities is expected to increase significantly from 30 percent of total registered businesses worldwide, and the share of women entrepreneurs with access to capital will rise from its current level of around 10 percent.[95]

Women's participation in economically productive activities is constrained by limited access to finance and lack of ICT skills. Presently, women have less access than men to both ICT education and financial services.

In order to increase the use of ICT among women, ICT education and capacitybuilding are key. In addition to basic ICT skills, higher (post-secondary) level ICT skills should be provided to help women take control of their own finances and leverage ICT for business activities. Product marketing in particular is a significant challenge for women entrepreneurs in developing countries, and information about marketing techniques and business affairs is not readily available. Once they have connectivity and are confident in using ICT, women can access online marketing as well as online news and information about business affairs.

These kinds of ICT-led financial services will reduce gender disparity by enabling women entrepreneurs to integrate their small businesses into local and global markets, helping them to become part of the formal business sector.

Case 5.7: Empowering Women for Financial Inclusion[96]

ICT must be leveraged to empower women through financial participation and achieve SDG 5 (gender equality), yet women face innumerable social, cultural, and broader systemic challenges that severely limit their demand for and thus use of digital financial services. These challenges include demand-side, technology, supply-side, and infrastructure barriers that limit women's financial participation—according to World Bank research, approximately 2 billion people worldwide currently lack access to formal financial services, and a disproportionate amount of this group are women. Not only are women on average less financially literate than men, thus translating into lower financial autonomy, many are also barred from accessing key identification documents needed to open formal accounts and are not privy to viable and necessary mobile technologies. Moreover, several social and cultural sanctions in developing countries prevent women from owning property or other physical assets, thereby unduly orienting financial participation toward men rather than both men and women.

ICT in the form of digital financial services can combat these challenges to champion financial inclusion, bridge the gender gap, and empower women through broad-based financial participation. Indeed, ICT-driven financial services offer a transparent, accessible, and affordable environment for women, encouraging them to save formally and increase their formal participation in the economy, further increasing women's labor force participation. Moreover, digital financial services allow for an increase in women's financial autonomy as they promote women's decision-making and greater control over finances, coupled with enhanced privacy features and fewer risks—travel and wait time for payments is reduced along with a reduction in the risk of cash confiscation or cash travel.

Lessons learned

Going forward, governments, commercial businesses, the technology and finance industries, and international donors must expedite women's financial inclusion via ICT by establishing a financial customer protection framework wherein women's financial participation is encouraged and further ensured. New technologies must be leveraged to increase female financial literacy, and favorable regulatory environments that work to reform discriminatory policies must be instituted. Large businesses should digitize their payment chains, paying wages through digital financial channels and electronic payments and encouraging widespread ownership of mobile devices, while international donors must fund this digitization and support the design of financial products and services to meet women's specific needs. Leveraging ICT to empower women through greater financial participation offers the key to macroeconomic growth and stability, essential drivers to all of the Sustainable Development Goals.[97]

5.6. Issues and Challenges

Achievement of the financial inclusion-related SDGs through ICT will not be without its challenges. While mobile banking and money is more accessible than ever before, there is still an opportunity to reach underserved segments, particularly women and rural consumers. Although the importance of an enabling regulatory environment is more widely recognized, regulatory barriers remain a constraint. As of December 2015, an enabling regulatory approach was present in 51 of the 93 countries where mobile money is available—up from 2014, where 47 out of 89 countries had enabling regulation.[98]

In their efforts to extend financial services to all through technology, policymakers and other stakeholders need to take the following issues into consideration (see Figure 5.5).

Education on digital finance: In poor countries where basic literacy levels are low, implementation of mobile money requires large-scale efforts to build digital as well as financial literacy. Even if the costs of ICT infrastructure and financial services are lowered, it will be difficult for consumers in developing countries to access and benefit from ICT-led financial services without basic knowledge of mobile platforms and financial products, special attention should be on groups such as women, elder or other groups not included in social systems .

Penetration rates: The experience of successful countries in increasing mobile financial services indicates that the most difficult aspect of expanding ICT-led financial inclusion is the initial push to increase customer use when penetration rates are low. Once a critical mass of usage is reached, the benefits that flow from financial services can yield a multiplier effect on economic

Figure 5.5. Making the link between SDGs and ICT-led financial services

Goal	Targets	Challenges	Objectives	Outputs	Outcomes
Goal 1: End poverty in all its forms	Target 1.4: Ensure that all men and women, particularly the poor and vulnerable, have equal rights to financial services including microfinance	Number of poor people is large and resources are limited	Enable access to resources, new technology and financial services	More people with access to Internet, broadband, mobile phone and financial services	Lowered poverty through ICT enabled financial services
Goal 5: Achieve gender equality and empower all women and girls	Target 5.b: Enhance the use of enabling technologies, in particular ICT, to promote women's empowerment	Increasing the use of ICT among women	Provide education to women and build their capacity to use ICT	More women with basic ICT skills; women with higher (post-secondary) level ICT skills	Control over finance by women increased; Women using ICT for their business, particularly for product marketing
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Target 8.3: Promote entrepreneurship and encourage micro, small and medium enterprises through access to financial services	Micro and SMEs lack capacity to use ICT-led financial services	Skills improvement and capacity-building	Cost reduction of micro and SMEs; women entrepreneurs encouraged	Employment and income generation through more micro and SMEs in operation; women's empowerment
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Target 8.10: Access to banking, insurance and financial services for all	Weak physical and social infrastructure	Increased investment for financial infrastructure, capacity building of individuals and enterprises	Financial infrastructure such as collateral registries, credit rating, credit bureau, payment and settlement systems; up-skilling of people in ICT	More people receive financial services
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	Target 9.3: Affordable credit for small-scale industrial and other enterprises, particularly in developing countries and integration into value chains and markets	High cost of financial services in developing countries due to low penetration and high interest rates; producers' share in the value chain is low	Lower services cost through use of ICT; access to market information through ICT	Low cost of financial services; higher product prices ; greater share in the value chain	More people involved in small-scale business; further opportunities for employment and income-generation.

growth. Numerous studies show that ICT affects economic growth only when penetration rate reaches 40 lines per 100 inhabitants.[99]

Distribution and agents: Securing an active network of agents is one of the biggest challenges in the adoption of mobile financial services. Agents remain the critical backbone of mobile money, digitising and disbursing cash. They also serve to educate consumers. Mobile money agents are a core part of the operational infrastructure and remain critical to the success of services. The number of registered agents continues to grow, but activating agents is a persistent challenge for providers.[100]

Regulatory framework: In many countries electronic transactions are currently heavily taxed. In order to increase affordability of mobile services and make it easier for non-bank financial institutions to reduce access barriers to banking services, governments should consider lowering tax on consumers and service providers and ensuring tax policies do not discourage investment in technology. In addition persistent legal uncertainties around e-commerce—including over payments, contracts, terms of delivery and guarantees—contrive to hinder electronic commerce, while business-to-consumer transactions continue to be hampered by concerns over security of payments, opportunities for redress and privacy of personal data. To address these deficits, skills and expertise shortages in establishing and implementing e-commerce laws need to be addressed. Finally harmonization of taxation, customs duties, data privacy and security will be essential to foster greater cross-border e-commerce.

Financial service costs: The costs of creating financial infrastructure and transaction costs for providing financial services to underserved populations can be high. ICT

can reduce the transaction costs of financial intermediaries such as formal commercial banks and microfinance institutions and expand their reach but markets have to have sufficient scale to make investments cost-effective.

High investment for physical and social infrastructure: Without investment in financial infrastructure financial inclusion cannot be expanded. ICT can lower implementation costs significantly by reducing the physical infrastructure required to provide financial services, but making the necessary investment is difficult for poor countries facing competing development priorities.

Product diversification: Product innovation is also essential in realizing the full potential of mobile money. In most countries there is a 'product gap' between the financial services offered to the poor and the services they actually want.[101] According to the International Finance Corporation (IFC), examples of mobile money in Brazil, Nigeria, Sri Lanka, and Thailand show that the most popular uses for mobile money were essentially moving money over distance but customers also want the ability to move money 'over time' in the form of savings, insurance and credit.

Near Field Communications and biometrics: In coming years, technological developments such as the rise of smart-phones, contact-less technologies like near field communications (NFC) and biometrics will have a significant impact on financial services.[102] NFC is a short-range mobile connectivity standard that uses magnetic field induction to enable communication between devices when they're touched together or brought within a few centimeters of each other. Through smart phones, more mobile

Case 5.8: SMART Rwanda leverages ICT for broad transformation

In a clear example of how a single country is embracing ICT to transform society on the path towards achieving greater sustainable development—and implementing many of the ICT-enabled solutions described in the previous chapters—Rwanda began in 2015 to implement its SMART Rwanda vision to become an information-rich and knowledge-based society and an ICT hub for the region.

Led by the Rwanda Ministry of Youth and ICT, a roadmap is being designed and solutions and services deployed to create a fully functioning knowledge-based society. The SMART Rwanda Initiative is geared towards connecting, innovating and transforming Rwanda into a knowledge and digital economy, thereby driving Rwanda's global competitiveness and job creation. The initiative also aims at enabling Rwanda to become a highly competitive, agile, open and innovative smart economy with the most favorable business climate that attracts large-scale investments, rewards entrepreneurship and enables fast growth and exports, leveraging ICT innovation to transform the nation into a smart society.

Ericsson is working closely with government and private agencies in Rwanda in a public-private partnership to scope the roadmap and implement solutions for SMART Rwanda, such as integrated transport, financial interoperability, smart utilities, public safety and security, to fully leverage the infrastructure investment and empower the people of Rwanda to reach their full potential. Rwanda is a member of the Smart Africa Alliance.

Among the objectives of SMART Rwanda:

- Increased access to financial services and information
- Introduce meaningful products and services for the under-banked and unbanked population
- Create an interoperable domestic and global financial ecosystem
- Increased government efficiency for collection and disbursement, enhanced by ICT
- Increased national competitiveness for growth and change in Africa

Services will be developed in three major segments: mobile financial services, banking and finance, and m-government services. Over time, interoperability will create an efficient financial system, will help connect a wider spectrum of financial institutions and address remittances, increase financial inclusion and government services, and drive the digital economy.

applications will become available. The need for interoperability—which describes the extent to which systems and devices can exchange data, and interpret that shared data—will become more important.[103] Contact less technologies will make transactions more efficient and secure, and the deployment of NFC will require new infrastructure for payments. Biometric data (the measurement and statistical analysis of people's physical and behavioral characteristics) of the global population will continue to grow in the coming years and will help with solving challenges related to digital identity (see Chapter 4).[104]

Stakeholder collaboration: Partnerships between banks, financial institutions, microfinance institutions (MFIs) and mobile industry players should be further encouraged to help scale mobile financial services. A single, interoperable integrated framework between financial institutions and the mobile industry can cut costs while delivering consumers the convenience of banking remotely. The ASBANC Digital Mobile Money project in Peru is a successful example of collaboration in next-generation mobile financial services (see Case 5.1.). Achieving financial inclusion by 2030 will require extensive collaboration and partnerships of this nature (SDG 17).

5.7 Conclusions

The success of future efforts towards ICT-enabled financial services will depend on a number of factors, as described in this chapter. The need for interoperability will become more important in order to secure nationwide scale up and cross-nation transactions. The e-commerce landscape must be enhanced for enterprises in developing and least developed countries so that businesses there can upgrade themselves to a technology-based business platform and remain competitive. Additionally, these other considerations must be taken into account:

First, there should be appropriate policies at the national levels integrating financial institutions with mobile providers in order to achieve financial inclusion through ICT. Given that there are several security and privacy- related issues in dealing with technology-enabled financial services, clearly spelt out policies and a strong regulatory regime should be in place.

Second, the adoption of technology will have to be accelerated through adequate financial and technical resources. Affordability of technology will determine use and uptake.

Third, dedicated efforts are needed to create the enabling ecosystems such as developing conducive regulations between banks, operators and agents, as illustrated by the Modelo Peru initiative led by ASBANC (see Case 5.1). Capacity building of agents is critical for distribution networks and integration in local communities and businesses and other locations.

5.8 Recommendations

ICT will expand online banking, payments, and support public-sector budgets and transfer payments. The 2030 Agenda sees financial inclusion (banking, payments, insurance and other risk protection, and other financial services) as vital for ending poverty (SDG 1), hunger (SDG 2), universal health coverage (SDG 3), gender equality (SDG 5), small businesses and entrepreneurship (SDG 8), sustainable infrastructure (SDG 9), and other Goals. Key elements include:

(1) Unique online ID for all citizens, following the India (Aadhaar) model or its equivalent.

(2) Use of e-payments by government for all public-sector transfers to households (paychecks, subsidies, reimbursements, salaries, etc.).

(3) E-payments for taxes and other fees.

(4) Education programs for all students on e-payments, e-Identity, e-governance.

(5) Public outreach campaign.

(6) Regulatory environment promoting e-payments by private companies.

6 ICT and Education

Embracing the Goals

SDG 4 sets out a bold education agenda with the aim of ensuring "that all girls and boys complete free, equitable, and quality primary and secondary education." It is supported by targets calling for:

- Target 4.1: All girls and boys to have access to quality early childhood development
- Target 4.2: Equal access for all women and men to affordable and quality technical, vocational, and tertiary education
- Target 4.3: That all youth and a substantial proportion of adults achieve literacy and numeracy
- Target 4.6: A substantial increase in the supply of qualified teachers

SDG 4 extends beyond the Millennium Development Goals' central focus on primary education enrollment. It emphasizes the importance of early childhood development through to secondary education and advanced training in skills or tertiary learning, and calls for universal secondary completion rates.

Five core values underpin the education-related SDGs: a) the right to education, b) equity in education, c) inclusive education, d) quality education and e) lifelong learning opportunities.[105] SDG 4 does not set out how its ambitious objectives can be accomplished but the creative integration of ICT into teaching, learning and education systems management will be essential.

Facing the Challenge

Education for all remains an elusive goal. Some 57 million children[106] of primary school age are out of school and universal secondary education remains a huge challenge for many low-income countries, notably in sub-Saharan Africa. Gross enrollment rates in secondary school remain below 50 percent in much of the region, with gross enrollment rates for higher-secondary education lower still—often under 30 percent[107] particularly in the Least Developed Countries. Lack of basic infrastructure and conflict-prone areas are key issues preventing 100 percent enrollment and school survival in sub-Saharan Africa. Adolescent pregnancy continues to be a key driver of dropouts in the region, resulting in the exclusion of girls from secondary schools. Even when good enrollment and completion rates have

been achieved, this can be offset by natural disasters or political uprising: in Syria, just two years of conflict after 2011 effectively erased 15 years of progress.[108]

The acceleration made possible by ICT has a key role to play in overcoming these challenges by driving advances in all aspects of education and helping to prepare students to contribute meaningfully to the Networked Society.

6.1 Introduction

Education is the single most important investment in long-term economic development once basic issues of survival and essential nutrition are addressed. Investing in education and skills—often termed human capital—accounts for a significant share of long-term economic growth[109] and is now recognized to be even more important than previously understood: quality education throughout the lifecycle, from early childhood through adulthood, is essential for achieving prosperous and inclusive societies.

The MDGs recognized this, and the SDGs are carrying this agenda further still. The MDGs made significant progress[110] in paving the way for universal primary education with a 42 percent drop in out-of-school children of primary-school age and an increase in the youth literacy rate from 89 to 91 percent.[111] Although the MDGs did not meet all their education targets—and outcomes varied across regions—progress since 1999 in the net primary enrollment rate has been striking. Between 1990 and 2012, the net enrollment ratio in primary schools in sub-Saharan Africa more than doubled from 62 to 149 million children.[112] Efforts to achieve MDG 2 have also given the global community invaluable experience and insight to draw on in achieving SDG 4.

UNESCO has underlined the importance of the education sector for achieving sustainable development outcomes in all other areas.[113] To harness the potential of education, five key areas for action were identified by global leaders at the World Conference on Education for Sustainable Development in Japan[114] in 2014: 1) advancing policy, 2) whole-institution approaches to learning and training environments, 3) increasing capacities of educators and trainers, 4) empowering and mobilizing youth, and 5) encouraging local communities and municipal authorities to lead education for sustainable development programs.

BAU won't deliver the results

Conventional education programming—in which the number of classrooms, teachers and supplies grow at the business-as-usual (BAU) rate—will not come close to achieving SDG 4. In Africa, for example, the enrollment rate in upper secondary education went from around 20 percent in 1999 to 35 percent in 2012.[115] Continuing at that rate of improvement might deliver a rise of 40-50 percent by 2030—far short of the 100 percent rate envisioned in Target 4.1.

> Education programs based on children's home languages have higher levels of participation, success and enjoyment [As well as parental involvement] and lower levels of repetition and drop-out, especially among girls."
>
> (UIS and UNICEF, 2015)

ICT's accelerator role is a powerful mechanism in every aspect of education: teacher training, local curricula, local-language instruction, monitoring and assessment of student performance, education-systems management, coaching and mentoring, and preparing students for a world in which ICT is a necessity for successfully navigating their future careers and lives and contributing to their national economies.

> With 3.1 billion people in the age group of 0–24, the education sector will immediately impact the lives of over 40 percent of the world's population, and will greatly affect the prospects for overall economic development.
>
> SOURCE: Data from the UNESCO Institute of Statistics website

"Education is the fundamental method of social progress and reform."
(John Dewey, 1897)

6.2 Education is central to achieving the SDGs

According to the World Bank Global Monitoring Report[116], which tracks progress towards global development goals, "Education's unique power to act as a catalyst for wider development goals can only be fully realized, however, if it is equitable." Beyond mere enrollment or completion rates, to meet the SDGs it is therefore vital that countries focus on the quality of teaching and learning in the classroom throughout the education lifecycle. That is a serious financial investment which is currently beyond the reach of most developing countries; innovative solutions such as those offered by ICT can go a long way in bridging the gap.

The total expenditure necessary to achieve the SDG education targets by 2030 is USD340 billion in developing countries with additional annual funding of USD39 billion to provide 12 years of free education.[117]

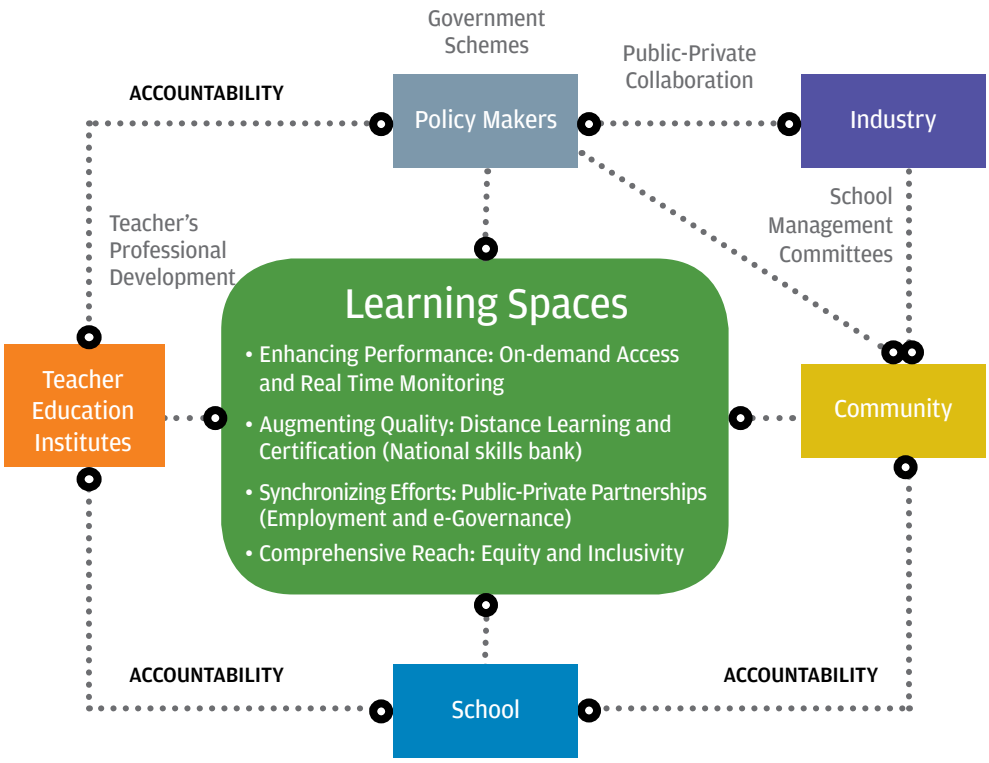
Source: Education for All Global Monitoring Report 2014, UNESCO

Quality of education is critical for long-term economic growth. Cross-country and cross-regional patterns of economic growth are strongly influenced not only by the number of years of schooling but also by the quality of schooling as measured in international comparative testing.[118] Studies have shown that the stronger a country's average test scores, the faster its economic growth.[119]

Early childhood development (ECD) has the highest return of all educational investment, providing an invaluable base for subsequent learning.[120] Experts have shown that deficits in early childhood development are difficult—if not impossible—to surmount in later years:[121] early childhood stress can lead to lifelong debilities, while early structured play with adults and other support in early childhood can improve executive function skills needed for lifelong learning, coping and problem solving.[122]

To harness the potential of education as a driver of human wellbeing and deliver the kind of progress envisioned by SDG 4 requires an enabling environment where adequate financial resources—including through private investment—

Figure 6.1: Conceptual Framework for Learning Spaces (Source: Earth Institute)



align with progressive policy, human capital and innovative technology to allow rapid scaling of development goals. Recent advances in ICT offer an attractive, innovative platform for curriculum development, training of teachers and other education workers, classroom instruction, mentoring, tutoring and coaching, as well as real-time collaboration and knowledge-sharing.

The framework shown in Figure 6.1 advocates a re-imagination of educational intervention and delivery, leveraging ICT, social capital, public-private collaboration and active participation of the community in decision-making to provide the necessary boost to achieve the SDGs by 2030. 'Learning Spaces' are educational environments that use ICT while preserving the core themes of equitable, inclusive and quality life-long learning opportunity.[123] Key elements of the 'Learning Space' include:

1) Enhancing performance: on-demand access and real-time monitoring.

2) Augmenting quality: distance learning and certification (national skills bank).

3) Synchronizing efforts: public-private partnerships (employment and e-governance).

4) Comprehensive reach: equity and inclusivity, including of ICT-based educational services.

6.3. ICT in action: Transforming education

ICT-based innovation is occurring throughout the education value chain. Recent ICT-based advances for educational systems include ICT for spatial planning, Massive Open Online Courses (MOOCs), and distance training, tutoring, and mentoring. Through ICT, the learning space is no longer limited to a traditional classroom, shifting educational delivery to the palms of every individual. ICT provides an unprecedented, cost-effective platform for governments, schools, teachers, communities and businesses to collaborate effectively and accountably in pursuit of SDG 4.

ICT can enhance education performance in a multitude of ways. It enables delivery of high quality content regardless of location. It provides a mechanism for ongoing teacher pedagogy, professional development and communities of practice. It can generate valuable data to assist with planning. Significantly, it also enables substantial reduction of delivery costs.

Through ICT, the learning space is no longer limited to a traditional classroom, shifting educational delivery to the palms of every individual.

6.4. A world-class education, anywhere in the world

ICT enables a unique opportunity for a world-class education, anywhere in the world, by rapidly disseminating quality content to end-users at reduced cost. Gone are the days when current curricula depended on printing and transporting often-outdated books to schools. Cloud-based systems with business models that require no or low upfront investments such as Connect To Learn lower barriers for schools to introduce a quality education (see Case 6.1) especially in more remote, rural, low-resource areas. The benefits accrue not only in educational content but also in student learning and teaching pedagogy and professional development.

Cloud-based platforms can also greatly reduce the operational costs of maintenance and connectivity. Broadband connectivity stands to enhance significantly the scale of digital education. High-speed streaming and maintenance at little cost can be a huge boon to service providers, creating multiple channels for content dissemination and ensuring a quick return on the fixed costs associated with content design and development and technology deployment. Pratham Virtual Open Schools (Case 6.2) showcases some of the salient issues in the use of ICT for content provision.

Support for teachers

Bringing education to students everywhere, with the help of ICT, is only part of the challenge. There must be sufficient teaching resources as well, and in many countries this is severely lacking. Sub-Saharan Africa faces the greatest challenges, with a total of 2.7 million teachers needed in schools today – and the situation will likely get worse as the region struggles to accommodate a growing school-age population.[124]

Teachers have an important role in guiding students to use ICT effectively. Increased access to professional development support and improved classroom management techniques help enhance teaching practice. In designing and implementing ICT teachers' training programs, the most successful outcome is when teachers learn how to integrate tools into teaching practice.

Teachers skilled in pedagogical uses of ICT can support quality, individualized learning opportunities for students. ICT can also contribute toward teachers' improved pedagogical skill, including but not limited to ICT-integrated pedagogies. While in-person support is always necessary for training teachers, especially those new to technology, ICT can offer a

Case 6.1: Expanding access to quality education with Connect to Learn

Connect To Learn (CTL) is a partnership of the Earth Institute at Columbia University, Ericsson and Millennium Promise, whose mission is to address the lack of universal access to quality education, with particular emphasis on the marginalized (especially girls) in resource-poor settings globally. CTL aims to achieve this mission by enabling access to quality instructional and learning resources through innovative teaching practices and technology tools in schools. It aims to ensure that each child is schooled at least to secondary level and equipped with 21st century skills to help increase their professional opportunities and improve their quality of life.

Founded in 2010, CTL initially deployed technology solutions in remote schools with few existing educational resources. The technology solution was designed to use mobile communications networks to enable access to quality education resources available via the Internet and to scale. The solution was optimized to run on low bandwidth and to serve teachers and students with little or no technical competence. The cloud-based solution aims to remove the complexities of virus protection, software updates, application installation and maintenance. This is especially important in areas with intermittent connectivity. A lack of ICT and pedagogical skills among teachers proved significant barriers in uptake of ICT integration in classrooms.

Lessons learned

A one-year Collaborative Action Research (CAR) study of secondary schools in Uganda and Kenya carried out by senior education researchers from the University of Nairobi in Kenya, Kampala University in Uganda, and Teachers College of Columbia University in New York[125], set out to deepen understanding of how to best implement ICT tools in secondary schools in resource-poor settings. By systematic implementation of ongoing teacher professional development to integrate basic ICT skills into teaching preparation and classroom practice, the study found significant increases in teachers' reported skill and comfort with using ICT for educational purposes, including in their observed use of ICT in the classroom. At the beginning of the project only 21 percent of teachers considered themselves to be 'advanced' users of ICT; by the end, 45 percent reported themselves to be advanced users. There was also an 18 percent increase in reported use of ICT in the classroom.

Other key insights:

1) School leadership is vital to drive integration of ICT tools and enabling environment for ICT in classrooms.

2) As teachers became more skilled, their perceived barriers to using ICT in teaching shifted.

3) Weak connectivity severely hindered teachers' efforts to find online resources; school servers populated with resources can supplement wi-fi routers.

4) Building confidence and skill of teaching staff and encouraging innovation in teaching styles through integration of ICT takes time and persistent effort. Sustaining progress requires continued and consistent support for teachers.

Applying lessons learned in Myanmar

The largest Connect To Learn project to date, funded by Ericsson and the UK's Department for International Development, is a partnership in Myanmar that includes Ericsson, UNESCO, the Earth Institute, the Myanmar Ministry of Education, Qualcomm, FinjaFive and EduEval. The program is being implemented in 31 schools. New locally relevant digital content is being created and delivered on a child-friendly interface and Ministry of Education officials are being supported to provide teacher professional development in ICT integration. The monitoring and evaluation framework first developed during the CAR study is now being extended and implemented in Myanmar to monitor the program's impact on student learning outcomes and girls' empowerment, and the framework will continue to guide all Connect To Learn projects going forward.

Source: Earth Institute and Ericsson

Case 6.2: Pratham Virtual Open School

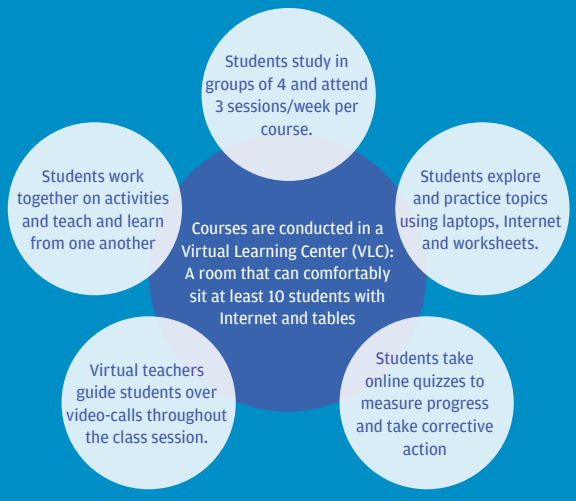
Pratham, India's largest education NGO, in partnership with the UN Sustainable Development Solutions Initiative (SDSN), launched its Virtual Open School program "Open Schools Online" in 2014, with the aim of leveraging technology to improve quality of education at scale in low-resource settings. Pratham's Virtual Open Schools (PVOS) project develops and demonstrates low-cost technology and pedagogy interventions that can be scaled to impact children's ability to learn, and thus their academic outcomes.

PVOS is an 'out-of-the-box' program to roll out Virtual Learning Centers (VLCs) within schools and communities. Designed as a two-year pilot aimed at 10-18 year olds, the program provides 'courses' that schools, NGOs and local educational entrepreneurs can offer to in-school and out-of-school children. In 2015-16, foundation courses in Math, English and computer usage were offered across two states in India (Rajasthan and Telengana) both in and outside schools, reaching approximately 2,500 students. Each course requires students to attend approximately thirty sessions of ninety minutes each.

For students, the course includes interactive course content to be accessed through a laptop or tablet and access to virtual teachers over Skype during every class period.

For schools, NGOs and education entrepreneurs, benefits include a web portal to register students and track their learning progress and learning outcomes, training for VLC facilitators and hardware set-up guidelines and support.

Figure 6.2. Pratham Workflow Diagram



In order to be able undertake program such as the PVOS, students must first have proficiency in basic Hindhi, Mathematics and English. To date Ericsson has partnered with the Pratham Education Foundation to support its Learning Excellence Program (LEP) in 28 schools in Gurgaon. The LEP offers teacher training that assists 2,188 students in English, Hindi and Math classes by training 55 teachers in these schools. All teachers are given training throughout the year with the intention of equipping them with the required skills to take students from one learning goal to another. The project also includes a library Program which provides assisted reading to all pupils in the school. The basic skills provided by this program are critical to ensuring their ability to effectively communicate and partake in digital literacy training and engaging with the digital economy.

Lessons learned

Initial results show powerful takeaways for educators and policymakers. Among them:

- Providing enough immersion time for students is essential to reap the benefits of the technology deployed.
- Incorporating technology into self- and group-learning instruction boosts self confidence of children , especially those who otherwise perceive themselves to be poor learners.
- Customized content tailored to learning in local languages and grade-appropriate levels is essential.
- Some students benefit most from smaller groups in which teacher interaction allows for individual tutoring and support.
- Interaction with the virtual teacher has removed traditional barriers to engagement in the classroom (such as viewing teachers as figures of authority) This encourages children to be more willing to ask questions.
- Technology enables immediate and actionable feedback for teachers, with every child's progress mapped in real time. This allows for faster response times from teachers and schools.

The PVOS model shows that technology can help overcome the initial barrier of learning, however this must be supported by careful design integration to ensure that children continue to learn and sustain their engagement and performance. The greatest potential of technology in education is its power to deliver large-scale improvements in student learning through a combination of self and group-learning content, structured sessions and accessible teachers. Without carefully integrating technology in the design of education delivery, its impact is likely to be limited. When introduced thoughtfully, it can transform the entire structure of the school system.

Geography counts when it comes to teacher presence, student school attendance and educational performance. When children in rural areas are far from schools, they are much less likely to attend and teachers are also far less likely to show up for work. ICT can pinpoint the geographical hotspots.

great opportunity for teachers to participate in blended models of teacher professional development.

Programs like Connect to Learn (Case 6.1.) are designed to address barriers to teaching by removing technical hurdles such as application updates, virus software etc. By managing everything in the cloud, CTL ensures teachers don't need to be IT experts, and can focus on teaching.

Programs like Intel Teach offer teachers interactive professional development modules on teaching methods that integrate ICT, as well as access to content and opportunities to interact and share ideas with other teachers around the world. The Teacher Education for sub-Saharan Africa (TESSA) initiative offers curriculum-aligned lesson plans, resources and opportunities for teacher interaction online, all designed by faculty from African colleges of education.

6.5. Gathering the data insight

Insight into the outcome of different educational approaches and investments will be instrumental in understanding progress towards the SDGs, and ICT can greatly enhance data generation and processing. In the last five years there has been a surge in research on data for education, and availability of timely and rich sustainability data is seen as a key tool for mitigating challenges and achieving the SDGs by 2030.[126]

To reap the benefits of ICT's data generation, teachers and school leaders need to be able to access and analyze information[127] through continuous professional development training as well as data collection of relevant indicators. Armed with that competence and insight, there is potential to greatly enhance educational capabilities in a region.

Access to quality assessment data in education is in its infancy compared with other high-performing industries.[128] Although standardized tests such as PISA provide a comparison for student performance, this information is of limited use in classrooms as it is not timely enough to guide teachers' instructional practice.

Continuous student monitoring, such as formative assessments, immediately highlights gaps in student understanding and supports instructional design. Access to real-time data helps identify gaps, successes and resources required to enhance strategic planning. Teachers using the Tanzania curriculum-aligned eLearning platform Studi have noted that the program helps them better understand where individual students are struggling via gameified assessment exercises.

Online questionnaires and data mining algorithms will permit much more accurate predictions of student performance and dropout risks, paving the way for preventative or corrective actions to keep girls and boys in school through secondary completion.[129]

6.6. Putting a better educational plan in place

Educational planning is integral to effective policymaking. ICT-enabled data gathering and geospatial analysis greatly increases the efficiency of the national planning process. One critical aspect of this is to create a geographical distribution of educational facilities that ensures equity in access and opportunity. Spatial data on education facilities can provide invaluable support for such educational planning. The Earth Institute worked with the Government of Nigeria to provide spatially based systems information at the national scale, using ICT, as discussed in Case Study 6.3.

The importance of proximity to schools as regards teacher presence, student school attendance and educational performance has also been confirmed by an Earth Institute analysis of a Millennium Development Village in Mali, where student attendance is high in the area proximate to the schools, beyond which it drops markedly. Similar observations have been made in Chile.[130]

6.7. Distancing learning and certification

Serving teachers and students in low-income rural areas is a significant challenge. Teachers are at the core of delivering and supporting education, especially with the ever-increasing demand to reduce the global student-to-teacher ratio. Yet the world faces a shortfall of teachers.

To meet SDG 4, strong emphasis needs to be placed on supporting professional development of teachers through teacher education and providing lifelong learning opportunities to create

Case 6.3: Nigeria MDG Information System[131]

The Earth Institute in collaboration with the Nigerian Government launched the Nigerian MDG Information System (NMIS), a web-based platform to equip the authorities with data-driven decision-making as a first step towards ensuring equitable and quality educational opportunity promised by SDG 4.[132]

The NMIS provides useful data that can facilitate real-time decision-making. Indicators such as spatial location of schools, enrollment, infrastructure, school resources, student and teacher attendance, school fees and school budgets provided information on the health of the education system with respect to the Millennium Development Goals.

Lessons learned

Integration of the NMIS increased the transparency of data and processes, and ensured that grant and aid reached the places that needed it most. The collection of data through ICT devices such as mobile phones ensured quick turnaround in the availability of the latest information relevant to stakeholders.

The NMIS indicators were developed collaboratively with the Nigerian government and sector specialists to ensure that the system is grounded in the Nigerian context. The involvement of local stakeholders was paramount as it ensured relevance of the system in the context and increased participation in the program.

The key lesson learned is that a national-scale, high-quality spatial inventory of facilities for a large country such as Nigeria can now be undertaken at low cost in a matter of months, not years.

a nurturing environment for high-risk students—no matter where they live. ICT can be mobilized for large-scale, distance student learning, teacher training and skill development.

The Indira Gandhi National Open University (IGNOU) in India is a prominent example of large-scale distance education.[133] The coursework is designed by professors from leading national colleges, with IGNOU responsible for the dissemination and testing of student work. MOOC-based instructional delivery promises to add immense value to the pedagogy of IGNOU and programs like it, as the MOOCs can provide a structured learning path for students while fostering communities of learners through the platform.

With the recent advent of Massive Open Online Courses (MOOCs) education is now available at zero marginal cost for anyone with an Internet connection. The total number of students who signed up for at least one MOOC course crossed 35 million in 2015, more that doubling from the previous year.[134]

Online education expands the ability to offer low-cost training to a much larger cohort of trainees, and may deliver educational benefits compared with traditional face-to-face instruction. There is evidence to suggest that blended learning—combining the two forms—is most effective.[135] The MOOC approach, whether as stand-alone online courses or blended courses, may provide the much-needed solution to "affordable quality technical, vocational and tertiary education, including universities" of SDG Target 4.3.

To meet SDG 4, various forms of blended teacher training will be vital for upgrading both the number and quality of teaching staff, given that current rates of teacher education are inadequate to achieve the goal.

Importantly, ICT helps foster strong, online communities of practice that enhance learners' interaction.[136] Such communities help individuals understand the importance of collaboration to support and transform their own learning, reducing isolation and reinforcing sharing, communication and exchange of best practice with supervisors and peers.[137]

Online platforms such as Coursera, EdX, EdCast, and Udemy host students from over 190 countries, including India, China, Brazil and Mexico, and provide technical and vocational training through curated and structured content and enhanced online social interaction. Coursera, the largest online course provider in the world, had 17 million students in 2015.[138]

Online learning platforms show great promise for accelerating literacy and numeracy efforts as large numbers of students can engage with the content simultaneously.

The traditional model of brick-and-mortar universities is running into supply constraints with steeply rising tuition and operating costs. Online courses or blended courses may provide the much-needed solution

The Jokko program, for example, was launched in Senegal by UNICEF in 2007 and aims to develop community literacy by "increas[ing] communication and collaboration within communities, with special emphasis on empowering women, through a mobile phone-based group message system."[139] Blended or hybrid course design also affords students engagement opportunities with a diverse student cohort.

For university-level online courses, the aim ultimately is to ensure that the online programs offer at least the same quality and rigor of instruction as those in leading universities. The UN Sustainable Development Solutions Network (UN SDSN), for example, is developing an online curriculum in sustainable development offered by world-leading academics, as discussed in Case 6.4.[141]

6.8. Leveraging public-private partnerships

ICT equips students, educators and administrators to perform tasks more efficiently and at lower cost. Public-private partnerships and impact investing can provide a key source of funding for global education, with private-sector educational content providers and trainers teaming up with governments to devise novel, cost-effective delivery models. A prominent example of how this works in action is the Connect to Learn program on Myanmar (Case 6.1).

With the financing gap for basic education growing, and education investments inefficiently allocated within countries, urgent action is required to close the gaps and achieve the SDG education targets by 2030. The International Commission on Financing Global Education Opportunity, led by former UK Prime Minister Gordon Brown, is tackling this by

Case 6.4: Training sustainable development practitioners[140]

Over a hundred thousand people from around the world have taken advantage of an online training platform on sustainable development called SDSNedu (www.sdsnedu.org). Launched by the Sustainable Development Solutions Network (SDSN), a global network of over 300 universities, to support the UN in promoting sustainable development, SDSNedu offers a set of high-quality, online courses offered by renowned global experts. The courses bring together the best available evidence and educational content on issues related to sustainable development, hosted on an interactive platform integrating videos, audio-visual and graphic elements to raise accessibility and engagement. The platform allows for student discussions and faculty engagement at a much more granular level than otherwise possible. In addition, the courses are made available for SDSN member institutions and other partners to use within their academic and training programs as core content.

Lessons learned

Experience with the first few courses has demonstrated that despite the rapid growth of online courses available through multiple platforms, there is an enormous demand for focused, high-quality courses that allow students to gain expertise and awareness about a key field (in this case, sustainable development) in a targeted, focused and interconnected manner. SDSNedu has also identified an enormous unmet demand from educational institutions, particularly in emerging markets, for locally tailored programs on sustainable development. The need for both global and locally specific content suggests the case for blended learning where students are simultaneously part of a global community while also being rooted in their local academic experience.

Transforming higher education

SDSNedu shows that higher education is poised for transformation—where global experts can reach several hundred thousand students, where the per-student cost of creating and running academic programs drops dramatically, and where connectivity ensures that students, irrespective of location, have access to high-quality learning materials. The success of technology in higher education will depend on 1) how it is used to create blended programs that are tailored to the specific needs of students; 2) how accreditation can evolve to benchmark global and locally relevant competencies; and 3) how well it can mimic the interactivity of a small classroom setting. Technology has the power to propel convergence in quality across institutions in developing and developed countries by referencing common learning standards—the SDSNedu experience is testimony to this power of large-scale educational change.

Gender-based disparities will be a pressing challenge for the SDGs. Over 400 million women in the world are unable to read full sentences. Of out-of-school children, 48 percent of the girls have never been enrolled in a school.

seeking out path-breaking research and policy analysis that create best practices to increase investments in education, and then motivating world leaders and private actors to commit to bridging the gaps.[142]

6.9. Achieving gender parity

Women and girls are disproportionately affected by the global education gap.

Gender disparity is even more prevalent in secondary education. In Angola, gender inequity has worsened from 76 girls per 100 boys in 1999 to 65 in 2012, while in conflict areas such as Chad there were roughly half as many girls as boys in secondary school in 2012.[143]

Child marriage and pregnancy of adolescent girls also contribute to increased female dropout rates. Initiatives that permit mothers to continue learning decrease dropout rates. As shown in Figure 6.3, on current trends, girls are far behind boys in finishing critical education milestones, and a BAU path will be incompatible with achieving SDG 4.

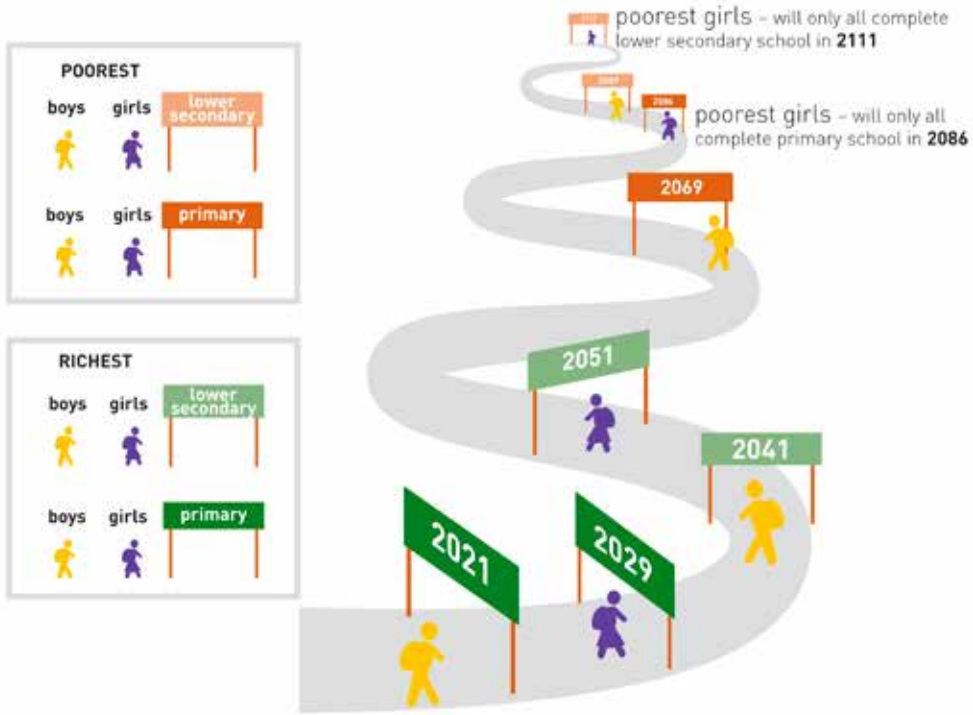
ICT-based remote learning opportunities are one way for girls to continue their education. The importance of ICT for gender parity is acknowledged in SDG target 5.b, which calls on development partners to "Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women."

Sexual education, provision of youth-friendly health services, counseling, gender awareness training and condom distribution in Kenya have also helped reduce pregnancies in targeted schools from 1 in 29 girls in 2006 to 1 in 97 girls in 2009.[145] Community-wide campaigns helped facilitate the reduction of child marriage in the Amhara region from 74 to 56 percent between 2005 and 2011.

ICT can also offer an e-counseling component. The Girls Exceling at Math and Science (GEMS) initiative, for instance, links secondary school girls to female professionals over Skype in order to engage in mentorship.

Various schemes and services aimed at educating girls and women is more easily disseminated, thanks to ICT, through web-based media, Internet radio and e-training initiatives led

Figure 6.3. The journey to complete education in sub-Saharan Africa[144]



by trained local community facilitators at early childhood centers, primary and secondary schools. ICT can also enable continuing education of adolescent mothers through distance learning platforms and ICT-based educational interventions.

Infrastructure also plays an important role in providing the enabling environment identified in SDG Target 4.a. Enrolment of girls in school is adversely impacted by an individual's distance from school: in Chad a study conducted in 179 villages showed that enrollment dropped dramatically when schools were in other villages, with the drop in enrollment significantly greater for girls than boys.[146] Growth in enrollment owing to the presence of a school in a child's immediate locality was also observed in Afghanistan, where villages with primary schools saw a 42 percent increase in enrollment with a greater proportionate increase among girls, thereby reducing the gender gap. The Earth Institute in collaboration with the Sustainable Engineering Lab at Columbia University have used GIS mapping of schools and children by age category to analyze the best locations for new schools.

Figure 6.4a. Gender Disparities in Primary School map from the UNESCO eAtlas

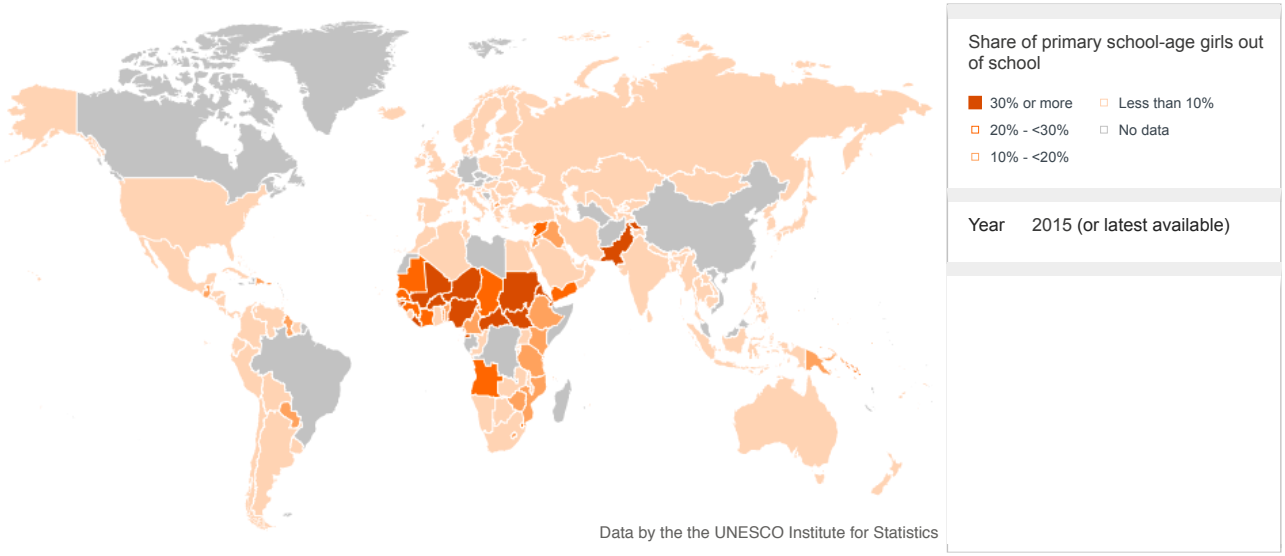
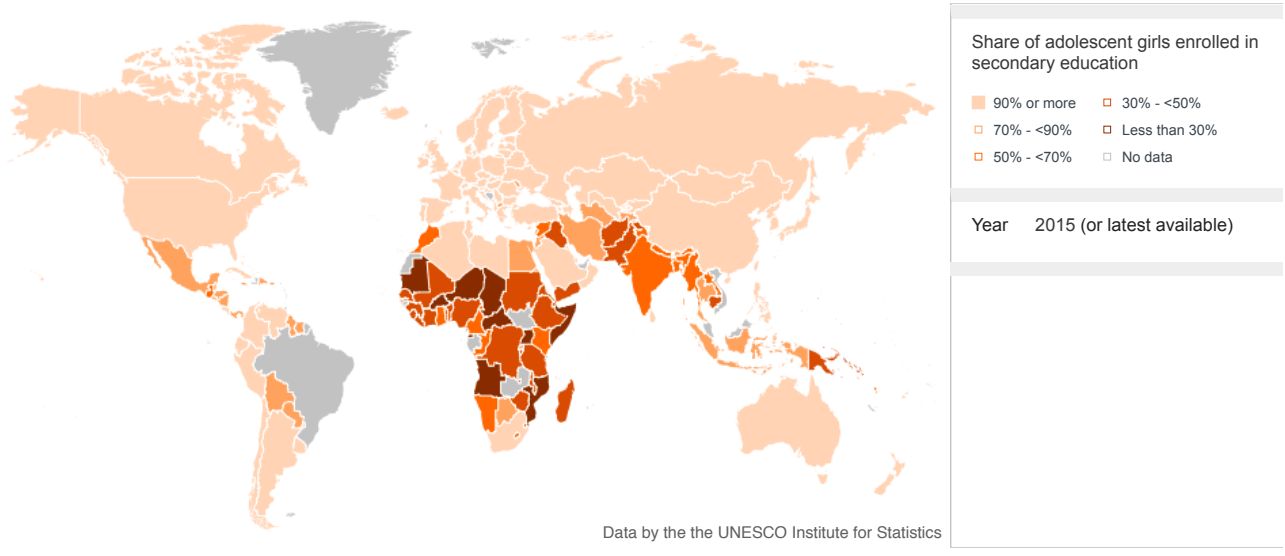


Figure 6.4b. Gender Disparities in Secondary School map from the UNESCO eAtlas[147]



6.10. Students with learning disabilities and special needs

Promoting inclusive societies and institutions, as called for under the SDGs, includes amplifying accessibility to persons with disabilities (PwDs). This entails removing barriers—so that persons with disabilities can use ICTs—and establishing enabling environments for ICT accessibility, including web accessibility. By offering alternative communications links, broadband technologies and services can help promote equal opportunities for PwDs.[148]

ICT and computers in general have been shown to help children with learning disabilities to make significant improvement in phonological awareness, word recognition and letter-naming skills.[149] Adaptive technologies such as language recognition (e.g. Dragon Naturally Speaking 8.0) and Braillex 2D screens for the poor can be deployed where needed through the cloud.

In Denmark, IT accessibility for people with impaired functionality is an important focus area in the achievement of joint public goals regarding full digital communication between citizens and the public sector. However, a 2010 Danish IT and Telecom Agency's 'Webtjek' survey of accessibility of public websites showed that there was room for improvement: only a little under half (48 percent) had few or no serious accessibility problems, while a little over half of websites surveyed (52 percent) had several functionalities or content that were not accessible. Following the survey, information and consultancy provision has been tightened up, and new e-learning modules on IT accessibility have been developed for a wide range of public employees.

Key success factors have included establishing a comprehensive monitoring framework based on industry-wide metrics and indicators. This is an important aspect of broadband and ICT deployment to ensure equal access for all. Government web accessibility includes surveying existing government websites to measure their accessibility levels in compliance with international standards, and setting targets for implementation of web accessibility guidelines by all government websites, including training of web developers. Valuable insights gained from surveys can help shape strategies to improve current policies and activities for overcoming the digital divide.[150]

6.11. Issues and challenges

Many challenges persist in the current education climate, ranging from inequalities in access, low quality of teacher training and curriculum, budget constraints, unstable political environments, local policy disconnects, lack of coordinated data systems to collect education statistics, and deficient childcare. A few issues and challenges within these areas are discussed below.

The majority of governments around the world still do not prioritize education in their national budgets. Education initiatives and institutions require significant resources to build up impactful education programs. If governments allocate less than the 20 percent recommended budget line to the education sector, many education policies likely will not be able to move forward. Additionally, governments still need to evaluate their education policies with regards to local context, taking into account local languages and cultural differences.

> Over the next 15 years, progress in SDG 4 will greatly impact the achievement of other SDGs. For example, the challenge of achieving health for all is fundamentally intersected with the challenge to achieve education for all.

As previously discussed, experts note that deficits in early childhood development can lead to lifelong debilities. The negative impact of deficient early childhood healthcare on education development is therefore a challenge that still needs to be bridged. Globally, one in four children are still short for their age—a sign of chronic deficiency in essential nutrients.[151] A number of drivers influence school dropout rates, from broader contextual factors in the family or community, to teasing, bullying, interpersonal relationships and mental health.[152] Holistic interventions that address these areas are therefore critical in achieving SDG 4.

Though the world has made great strides in advancing primary education for all, the challenge of post-primary education remains. The transition from primary to secondary school remains disparate, particularly for lower income families. According to UNESCO's Education for All report, in the Phillippines, "69 percent of primary school graduates from the poorest families continued into lower secondary, compared with 94 percent from the richest households."[153]

Another increasingly urgent issue is the challenge to provide education in conflict zones.[154] The dearth of trained teachers,

access to safe schools, and health issues all contribute to poor education in conflict zones. Continued advocacy, international action, as well as ICT initiatives such as remote learning, could be utilized as intermediary actions. However, the unique challenges of bridging the gaps around providing stable education in conflict zones still need innovative solutions.

6.12. Conclusions

Innovative solutions that employ ICT will be fundamental for empowering education leaders and communities to achieve the goal of SDG 4, Education for all.

Achieving SDG 4 will require collaboration between local, national and international stakeholders—both internal and external to the schooling system—with shared accountability and commitment to the common goal of universal, quality education.

ICT services for remote distance learning and teacher training, education data collection, and other cases discussed in this chapter will allow leaders and communities to address issues of access and inequality in attaining human capital for female, lower income, and special needs members of society. Properly evaluated ICT interventions can enhance the potential for a quality education by removing socio-economic constraints, opportunity costs, language of instruction, and preventing health deficiencies.

Greater focus on online learning must be matched with credible coursework certification to satisfy potential employers and ensure entry into further education. Numerous organizations are now attempting to provide credit equivalency or certificates for online programs for acceptance by employers.

The success of SDG 4 will depend on innovative, multi-stakeholder strategies to empower grassroots community leaders to address the compelling shortages of trained teachers and quality school curricula; to help curb dropout rates in secondary education by making it more affordable, practical and accessible; to improve access and quality of programs for early childhood development; and to remove socio-economic constraints—such as disparity in gender roles, poverty, opportunity costs of schooling, language of instruction and other inequities in educational opportunity based on ethnicity, local violence and conflict, or special needs of individual children.

6.13. Recommendations

SDG 4 calls for the dramatic scale-up of quality education from pre-K to secondary completion. This will be achievable only with a powerful and intensive use of ICT for education, by 2020 or earlier. With early and immediate targeted interventions, education can be transformed and SDG4 targets achieved far more rapidly. Priority interventions include:

(1) Connectivity of all schools, primary, secondary, and tertiary, to mobile broadband.

(2) National teacher training in ICT equipment and applications.

(3) Development of online curriculum in local languages as appropriate for lower levels, and national languages for upper levels.

(4) Training of students in ICTs (computers, coding, ICT applications, etc.) at all levels of schooling.

(5) Development of and access to existing online courses (MOOCs) for high-school and tertiary education, with accompanying print teaching materials.

(6) Creation of free, online libraries with e-books, e-journals, e-magazines for use in all low-income countries.

(7) Introduction of online monitoring of schools (teacher participation, student attendance, Internet usage, supplies and inventory management).

(8) E- or mobile payments for teacher salaries and other Ministry of Education outlays.

(9) Deployment of Community Education Workers (CEWs) akin to Community Health Workers (CHWs) to help schoolchildren in need.

(10) Use of video-linked classrooms to extend the reach of the nation's best teachers and schools.

(11) Online national testing of students at least once per year.

(12) Real-time cloud-based policy dashboards for education managers, including school enrollments, attendance, and performance (including test scores).

(13) ICT technologies for special needs, including voice recognition, online Braille, and others.

(14) Scholarships for students from developing countries, including "vocational and information and communications technology, technical, engineering and scientific programmes" (Target 4.b).

7 ICT & Health

Embracing the Goals

SDG 3: 'Ensure healthy lives and promote wellbeing for all at all ages' not only targets access to basic health, but acknowledges that health means enjoying wellbeing throughout one's life. It aims for an inclusive health delivery system in which neither location, income, race nor gender represent barriers for quality access to healthcare and wellbeing.[155]

Its 13 targets build on progress made under the MDGs and reflect a new focus on non-communicable diseases (NCDs) and the achievement of universal health coverage. While SDG 3 is specifically focused on health, almost all the SDGs are directly related to health or will contribute to health indirectly—for example SDG 2 'end hunger, achieve food security and improved nutrition …', SDG 6, 'to ensure availability and sustainable management of water and sanitation for all'; SDG 13, 'take urgent action to combat climate change and its impacts', and SDG 16, 'peace, justice and strong institutions', as peace and stability positively impact the mental and physical health of populations.

Facing the challenge

Over the past 15 years the MDGs advanced global health in many areas, turning around the epidemics of HIV, malaria and tuberculosis and increasing access to safe drinking water as well as making substantial progress in reducing child under-nutrition, maternal and child deaths and increasing access to basic sanitation.[156]

But wide gaps still exist between—and within—countries, and continuing effort is needed to reduce the rate of child and maternal mortality. Over six million children still die before their fifth birthday each year and the maternal mortality ratio—the proportion of mothers that do not survive childbirth compared to those who do—in developing regions is 14 times higher than in developed regions.[157]

With new HIV infections on the decline, the target of achieving universal access to treatment for HIV will be more challenging. HIV is the leading cause of death for women of reproductive age worldwide and adolescents (aged 10–19) in Africa, and the second most common cause of death among adolescents globally.[158]

With NCDs such as heart disease, cancer and diabetes accounting for two-thirds of deaths worldwide and on the rise in both developed and developing countries, this is also an enhanced focus area of the SDGs.[159]

Other serious challenges confronting the global healthcare system include the unsustainable cost of care in many countries, lack of access to quality care, inadequate governance structures making it difficult to respond to epidemics, and regulatory frameworks that fail to keep pace with technological advances and innovation.[160]

In all aspects of the global health challenge, ICT can play a decisive role in accelerating progress towards SDG 3.

7.1. Introduction

Major strides have been made over the past two decades on the state of global health, in areas such as child and maternal health, communicable and non-communicable diseases. The total number of deaths annually among children under five has been halved over the past 40 years.[161] Over 6.2 million malaria deaths were averted between 2000 and 2015, the global incidence rate has fallen by around 37 percent and mortality rates by 58 percent.[162] Between 2000 and 2013, tuberculosis prevention, diagnosis and treatment interventions saved an estimated 37 million lives.[163]

Yet the scale of the challenge to achieve SDG 3 remains huge, particularly in sub-Saharan Africa and parts of South-East Asia. Malaria and other tropical diseases still present a significant challenge. According to the World Health Organisation[165] the main causes of death have shifted from communicable to non-communicable diseases (NCD) including cardiovascular disease, cancer and obesity, among others.

Uneven burden

To achieve SDG 3, the global disease burden gap presents a range of challenges to overcome. In low-income countries, chief obstacles are insufficient human resources capacity, poor infrastructure, low-quality healthcare delivery, mismanagement of human resources and administrative processes, and miscommunication across the health system. In middle- and high-income countries, overcoming economic constraints to upgrade quality and improve efficiency is needed.

Based on current GDP forecasts, global health care spending should grow more than 6 percent annually over the next decade.[166] For emerging market and developing economies, the health share of GDP is expected to rise by 1.7 percentage points over the next 10 years.[167]

Investment in public health funding saves money when the investments are well-targeted to meet the needs of a specific country. One of the biggest challenges is how to maximize resources and capabilities to improve efficiency and equity in the health sector.

A challenge that applies to both developing and developed countries is that governments and other institutions and organizations in the health sector are faced with reducing expenditure and costs without affecting access to and quality of healthcare delivery, and/or driving efficiency in the collection of income and revenue allocated to the healthcare bud-

Figure 7.1: Countries with persistent malaria burden. (Source: World Malaria Report 2014)[164]

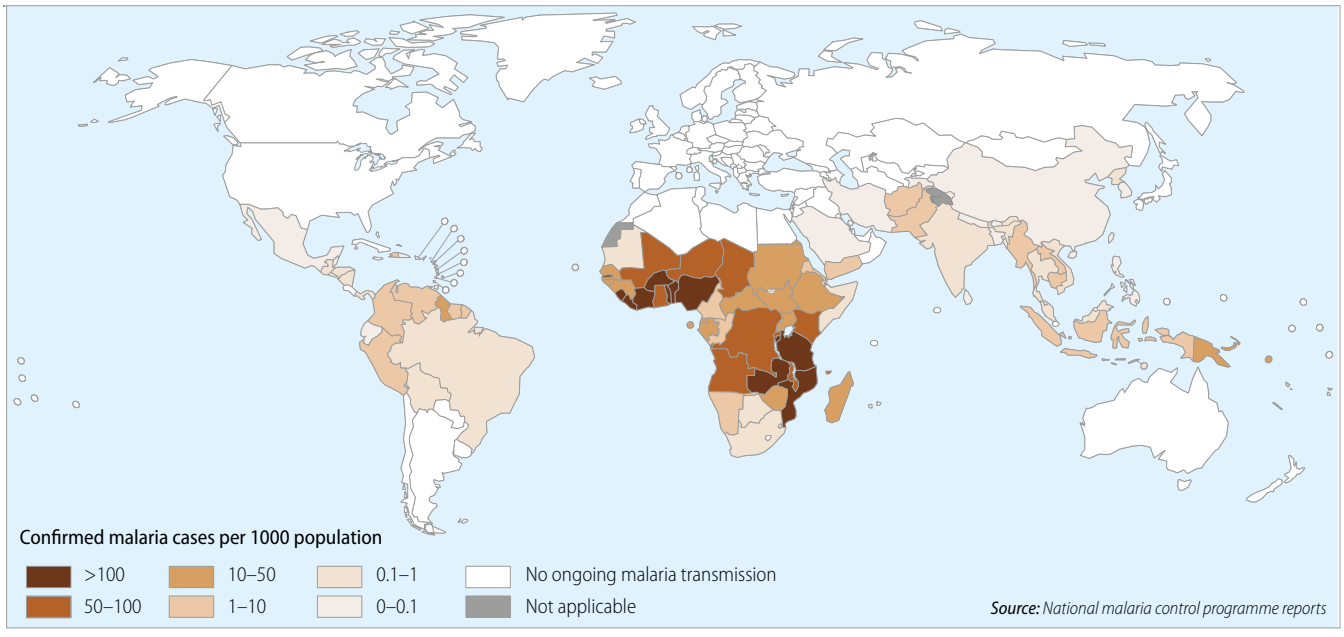
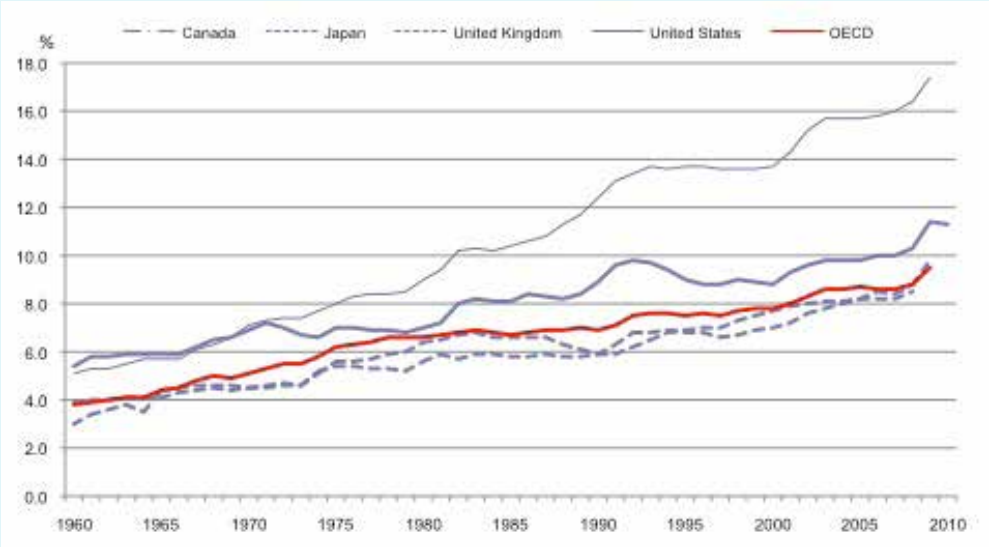


Figure 7.2 Health expenditure as share of GDP, 1960-2009, selected OECD countries[168]



get. ICT can help find new ways to boost efficiency. Figure 7.2 shows the general increase in health expenditures as share of GDP between 1960 and 2009. Given the still significant gaps in healthcare spending, the increases may be explained by ICT driving improvement in quality rather than lower costs.

Cost reduction through ICT

While ICT can help to reduce health costs over time, many countries face budget constraints in making the initial ICT investments. This presents a major hurdle, despite the major savings that can accrue. For example, Eritrea, a Least Developed Country, spends USD 12 per person year on health (the world's lowest), making major investments in devices and other types of technology prohibitive.[169]

Cost reduction can be achieved through disease surveillance, preventive campaigns and treatment compliance to make healthcare delivery more cost-efficient. Studies on the impact of health information technology on quality, efficiency and costs of medical care demonstrate three major benefits:

- Increased adherence to guideline-based care and improved targets for chronic diseases.
- Enhanced surveillance and monitoring.
- Decreased medication errors.[170]

Preventive health showed the greatest improvement through the use of ICT, since it decreased the need to use valuable healthcare resources.[171]

A European Union analysis of the impact of mHealth on reducing health costs showed that healthcare systems in the EU could achieve the following:

- Savings of EUR 99 billion in total annual healthcare spend in 2017, after the cost of extra workforce to support mHealth. These savings will translate to EUR 76 billion of public expenditure and EUR 23 billion of private expenditure—which equates to treatment of an additional 24.5 million patients against a constant number of doctors and facilities.
- Some 185 million patients helped to lead healthier lives and gain 158,000 years of life.
- Of the total 185 million patients who can potentially benefit from mHealth, 141 million could improve their lifestyle through changing how they manage their medical conditions and successfully address one or more lifestyle disorders. Another 54 million could avoid the risk of developing them and a further 26 million patients, who are ageing, could become more involved in managing their care and lifestyles.[172]

The EHAS Foundation in Latin America has also carried out studies on the economic factors affected by using telemedicine. It found that the net economic effect of pilot telemedicine programs over a four-year period was clearly positive, and that the savings produced for the healthcare network thanks to the reduction in patient referrals and associated costs were greater than the additional operational costs incurred by the telemedicine system.[173]

A number of cost benefit analyses confirm that savings outweigh costs, indicating substantial potential savings from electronic health records, healthcare information exchange and interoperability. Quantifiable benefits are projected to outweigh the investment costs, however, the predicted time needed to break even varied from three to as many as 13 years.

Managing rising health costs will be a challenge for all countries, but particularly for developing countries already struggling to meet their healthcare needs. Without the budget for a world-class health system, developing countries need the kind of leapfrog mechanism that ICT can deliver. Countries that are experiencing a shift in disease burden and mortality to NCDs, in line with an aging population, face a potentially explosive growth in health spending due to the increasing prevalence of chronic conditions.[174] The innovative use of technology can help.

ICT provides a pathway to better health

For countries and regions facing extreme poverty, the most effective health interventions are often the most basic, such as washing hands, reducing indoor crowding, eliminating open fires indoors, providing water, sanitation and nutrition, improving women's rights, fighting corruption, and addressing cultural beliefs about health that may affect how an intervention is received.

While much progress remains to be made in taking these basic steps in the poorest parts of the world, many governments are starting to recognize ICT as an innovative and effective means to maximize limited healthcare resources and deliver high-quality health services a lower cost. Enhanced information exchange, both between institutions as well as patient and doctors, increased data availability and improved data processing can help upgrade health systems worldwide. Universal access to high quality information will improve service delivery, encourage behavior change and empower people to make informed health decisions.

In 2005 WHO urged member states to endorse eHealth as a way to improve and strengthen healthcare access and delivery. Studies have shown positive impact on health systems in developing countries where eHealth pilot projects have been implemented. ICT-enabled solutions improve communication between patients, community health workers and health facilities, particularly in remote and rural areas.[175] They also enhance treatment compliance,[176] maternal and newborn health programs,[177] monitoring and disease surveillance systems, data collection for disease outbreaks;[178] as well as management and logistics[179] efficiency.

Scaling up solutions

Successful pilot projects can be scaled up to plug gaps, strengthen communication and information linkages, and deliver better ways to evaluate impact across entire national health systems.

Research[180] highlights three areas where ICT could add system-wide value in low-income settings:

- Extend geographic access to healthcare.
- Improve data management.
- Enable communication between patients and physicians outside health facilities.

By identifying key constraints in existing health interventions, appropriate, human-centered eHealth strategies can be designed and cost-effectively deployed.

7.2 ICT in action: Transforming health

To make real headway in achieving SDG 3 and its targets, national health systems need better integration—an area where ICT can play a crucial role by improving linkages and making good data available for continuous improvement of health outcomes.

There are six main ways that ICT can help:

1. **Interconnectivity** and efficient information flow between different parts of the health system, exemplified by telemedicine and supply chain linkages.

2. **Upgraded quality** of healthcare delivery for remote/rural areas to create a 'ubiquitous' healthcare delivery system, through interconnected national databases and greater communication capability for community healthworkers (CHW) via ICT.

3. Increased access to quality data for **accountability** and continuous improvement of health programs. Enhanced exchange of data and best practices in health interventions paves the way to learning societies where lessons learned are shared across countries and regions.

4. **Cost-effective** healthcare systems where ICT-enabled solutions reduce costs and improve efficiencies at national or regional level, helping to extend health budgets.

5. **Empowered patients** with basic primary healthcare knowledge as well as self-assessment tools to improve personal wellbeing and reduce healthcare costs through preventive medicine.

6. Efficient **disease surveillance** and reporting systems that boost health outcomes and avoid the negative impacts of disease outbreaks.

The future of health systems will be guided by human-centered design technologies that use ICT to tackle constraints and target efficiency gains to ensure universal quality healthcare.

7.3 Interconnectivity: Bringing it all together

The components of a national health system should work closely together to deliver quality patient healthcare services. ICT can help overcome the current disconnect between different parts of the health system, directly benefiting target 3.8 of SDG 3, which aims to achieve universal health coverage (UHC) and includes access to quality essential healthcare services and essential medicines and vaccines for all.

For health management at a district level, improved communication helps eliminate duplicate information, allowing better information flow between different units, improving efficiency. Health management at this level is particularly important in developing countries where human capacity and poor infrastructure typically mean decision-making is centralized in urban centers, leaving rural areas with smaller health management units.

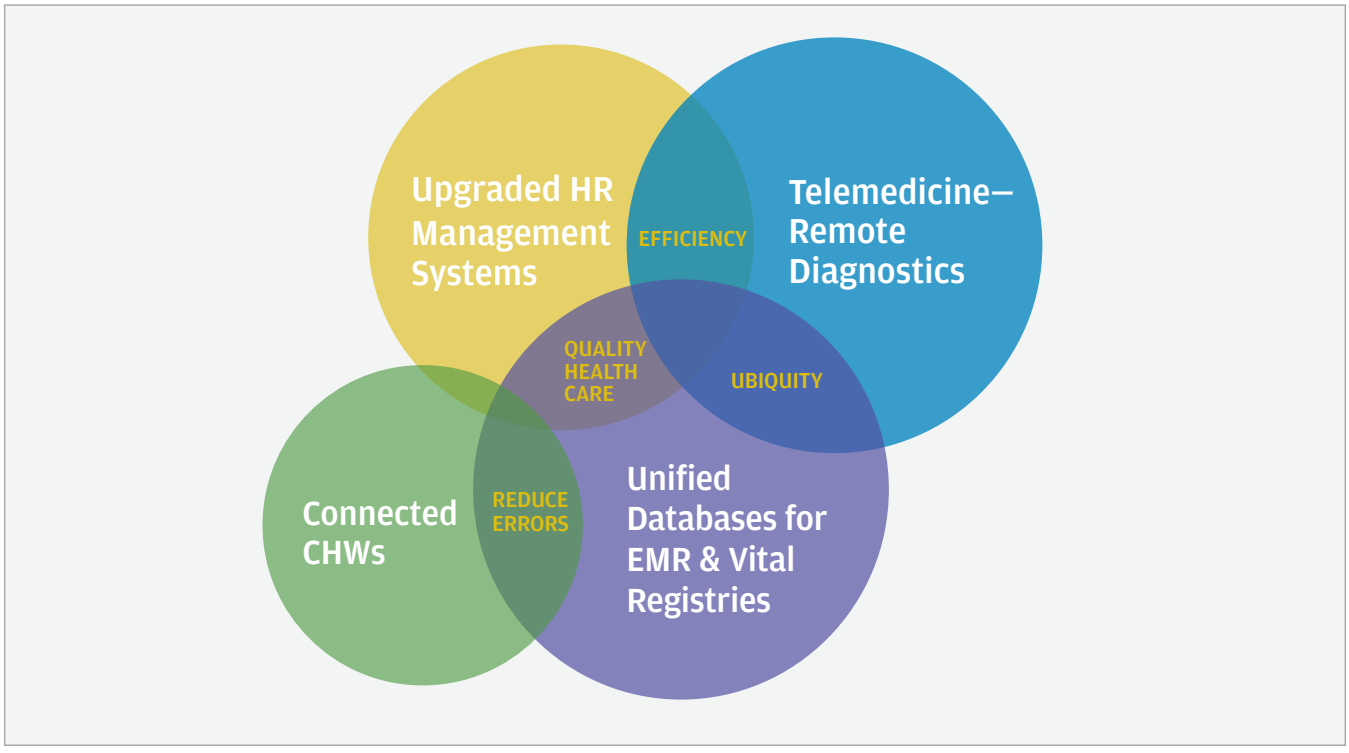
Telemedicine plays a crucial role in healthcare coordination between providers and patients. It has been shown to improve planning and project management, increase accessibility of up-to-date, real-time information about patients, raise the likelihood of detecting misdiagnoses in time, reduce errors from health providers, and enhance patients' treatment compliance.

Supply chain management

The medical supply chain presents a considerable challenge in many parts of the world, due to broken linkages between the supply chain system and healthcare providers. Tracking and processing information on the supply and demand of medicine is difficult, especially in rural and remote areas in low-income settings. In addition, serious challenges such as counterfeit drugs can pose potentially grave health risks to consumers.

Evidence suggests that electronic supply tracking has a positive impact on inventories.[182] ICT systems could also support cost reduction and cost-effectiveness through better utilization of resources, since stock demand/supply mechanisms can be tracked in real time—a benefit for middle and high-income countries seeking new ways to optimize budgets and healthcare expenditure and personal wellbeing.

Figure 7.3 Using ICT to upgrade healthcare delivery[181]



One example of supply chain management in action is Tanzania mHealth malaria stock tracking. A total of 130 clinics use the SMS for Life mHealth supply chain system to prevent stock-outs of essential malaria drugs.[183] According to one study,[184] the proportion of malaria stock-outs in three Tanzanian districts declined from 78 percent in the first week to 26 percent by week 21. Additionally, the research showed stock increased by as much as 64 percent.

Other possible solutions include utilizing barcode technology to scan medical supplies at different points in the supply chain and transmitting this information in real time through the Internet. Barcode scanners are already present in the market and extend to other areas of healthcare such as admissions, point-of-care and specimen collection.

Telemedicine crucial in rural areas

There are countless examples of SMS-based telemedicine being used to improve healthcare delivery, especially in rural areas between Community Health Workers (CHW) and healthcare management units. One of the first such initiatives was in the Millennium Villages where Ericsson provided mobile connectivity to the villages, and then also provided some 2,000 mobile phones to CHWs between 2007-2009 in 10 countries where the project was running. In 2013, the phones were upgraded to smart phones to enhance the quality of information and service provided by the CHWs.[185]

In Malawi, SMS has been used to improve health services at community level to manage logistics, report events and address emergencies.[186] In Indonesia, use of mobile phones to improve communication between midwives and CHWs in rural areas was associated with an improvement in healthcare system processes: facilitation of communication, greater time efficiency and better access to medical information.[187]

Such initiatives have greater impact when scaled up, as demonstrated by NGO[188] Switchboard, which has partnered with telecom operators in Ghana, Liberia and Tanzania to create a 'closed user group' network in which physicians can call other healthcare providers for free or at reduced prices for advice and referrals.

MazikCare, hellohealth platform[189] and sensei[190] are examples of unified solutions that channel telemedicine to boost coordination within healthcare systems. They feature software that can operate on tablets, smartphones and computers connected to the Internet, providing real-time updates on patient health status and connecting all healthcare providers on one platform. Additionally, it processes e-prescriptions and sends them directly to the pharmacy. At present there are several ICT-enabled products and solutions that provide these functionalities. If scaled up at a national or regional level, with adequate infrastructure, they have significant potential to accelerate progress towards universal health coverage.

7.4. Increase health budgets through use of ICT

Most developing countries have budget constraints preventing them from increasing the amount of income allocated to health in the short term. But ICT can deliver new ways to improve efficiencies in health financing systems. New insurance and tax collection tools are leading the way in providing a sustainable mechanism to ensure health for all.

According to the World Health Organization (WHO), health insurance is a promising means of achieving universal healthcare coverage by giving[191] a population access to prepayment and pooling mechanisms.[192] Improved collection of data through ICT helps to implement insurance for all in three ways:

1. For an effective insurance system, patient specifics and information are required.

2. ICT is essential for collection of information.

3. ID systems need to be in place to ensure consistency and reliability of patient information.

Optimize tax revenues

Few least-developed countries are currently able to finance a system of universal coverage—even with modest health services—from their own domestic resources. To allow them to scale up more rapidly, enhancement of tax collection systems should occur through use of ICT and data collection mechanisms.[193]

Even in high-income countries, tax avoidance and inefficient tax and insurance premium collection are serious problems. The practical difficulties in collecting tax and health insurance contributions, particularly in countries with a large informal sector, are well documented. Improving the efficiency of revenue collection will increase available funds to provide services. Indonesia, for example, has totally revamped its tax system with substantial benefits for overall government spending, and spending on health in particular.[194]

7.5 Quality access: Improved provision of essential services

Many health systems, particularly in developing countries, face a considerable economic hurdle to achieve universal health coverage (UHC) for all. Access to quality healthcare in

Doctor using the digital stethoscope developed by EHAS Foundation
Source: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4197650/

many low-income countries around the world is stymied by insufficient healthcare budgets, lack of human resources, inadequate infrastructure and the lack of strong communication linkages within the health system.

Evidence suggests that information processing through ICT could be key to accelerating provision of health for all at a macro level. According to research conducted by WHO,[195] the chief barrier to achieving UHC is economic. A rise in income level and economic growth are necessities, allowing the private sector to provide insurance for workers while increasing per capita tax revenues to ensure the sustainability of the system. Labor force capability and information processing capacity to ensure good administration and correct provision of health services are also important.

In countries with profound differences in health infrastructure between urban and rural areas, improved information systems are critical to accelerate access to quality healthcare. The main challenge to provision of quality health services is lack of infrastructure and a need for improved exchange, quantity, quality and accuracy of information. Quality healthcare access also includes access to safe and effective medicines and vaccines, another current barrier in the developing world.

As well as telemedicine, ICT can boost access through remote diagnostics, electronic medical records (EMR), vital registries, unified databases, upgraded human resources methods and communication systems to improve linkages and performance of CHW in rural areas. Scaling such initiatives could greatly impact progress on SDG 3.

Remote diagnostics

With high rates of mobile penetration worldwide, telemedicine is a reality in many parts of the world, allowing people in remote villages to enjoy quality healthcare delivery. Maternal mortality indicators have been positively impacted through ICT, not only through better communication between healthcare providers and mothers, but also thanks to innovative devices that can perform remote diagnostics. There is growing interest in adapting traditional medical instruments such as microscopes, ultrasound scanners, etc. to mobile operating systems such as android or iOS to enable remote consultation.

One example is the digital stethoscope, where audio and video are sent in real time to a remote doctor who can determine the position of the stethoscope using sound and ask the technician to change the stethoscope's position and relay instructions to the patient. This gives the doctor crucial information needed to make a remote diagnosis. The stethoscope also allows sound recording so files can be sent for a second opinion.[196]

Electronic medical records

Interconnected and unified databases that include electronic medical records (EMR) and vital registries enabled by ICT are another means to enhance quality access to healthcare. Using technology to track spending and measure outcomes will be increasingly important in managing cost-constrained health budgets. Healthcare information technology, such as EMR and analytics software, can help standardize care, improve outcomes and influence healthcare reimbursement.

Singapore launched the first phase of its National Electronic Health Record (NEHR) system,[197] OpenMRS. This allows frontline health workers to access information from a patient's health record using a mobile device and to add information to the health record—for example, about field-based tuberculosis treatment. Other systems, such as RapidSMS or ChildCount+, might not be linked to a clinical file but can maintain longitudinal client histories, such as antenatal care documentation, infant and child growth records, and digital vaccine records.[198]

The ability of Electronic Health Records (EHRs) to improve the quality of care in ambulatory care settings was demonstrated in a small series of studies conducted at four sites (three U.S. medical centers and one in the Netherlands), according to the National Institutes of Health in the US. The

studies demonstrated improvements in provider performance when clinical information management and decision support tools were made available within an EHR system, particularly when the EHRs had the capacity to store data with high fidelity, to make data readily accessible, and to help translate this into context-specific information that can empower providers in their work.[199]

Electronic systems for vital registries and smart cards are helping to overcome barriers to access to health. A growing number of registries are mobile-based, such as the Mother and Child Tracking System (MCTS) in India[200] and UNICEF's birth registration system in Uganda.[201] Researchers have found that mobile phone-based registration systems facilitate identification and enumeration of eligible clients for specific services, not only to increase accountability of programs in providing complete and timely care, but also to understand and overcome disparities in health outcomes.[202]

In India, RSBY, a health insurance scheme for families living below the poverty line, offers biometric smart card technology that provides verifiable identification of the beneficiary, validation of available insurance coverage without documents, use of a health insurance card across states and insurance providers, and a multi-network vendor for operations (see Chapter 2, Digital Identity and the SDGs). The scheme can also easily be expanded to other social security schemes. RSBY's robust technology platform has helped to standardize operations across all stakeholders.[204]

Case 7.1: Effective outreach in Latin America

The Enlace Hispano Americano de Salud(EHAS) is a research and non-profit institution with the goal of improving healthcare services in isolated rural areas in developing countries, through appropriate design and use of ICT. EHAS analyzed communication and information needs in rural primary healthcare in developing countries with the aim of improving diagnosis capabilities of rural health centers or health posts using open software and wireless devices. The intention was to allow doctors to remotely support health technicians using real-time communications tools based on voice and video.

EHAS found that remote consultation had great advantages. Patients feel safer knowing that a doctor is helping with their diagnosis. These systems increase patient willingness to attend health posts in regions where reluctance to use modern medicine is a challenge. In addition, health technicians can improve their training and provide better service to patients, which make the providers feel more confident. A remote diagnosis allows many diseases to be treated at the health post, making it unnecessary to transfer the patient to another health center in an urban area, saving costs for the patient and the health system.[203]

Case 7.2: Rapid diagnostics for maternal health

Remote diagnostics through portable devices can play an important role in improving maternal and child health and quality of healthcare delivery in rural areas. Empowering mothers through information and ICT will improve national health standards and a number of small-scale projects are showing good results using remote diagnostics to improve maternal survival through on-time diagnosis of future complications.

The EHAS Foundation in Latin America is currently evaluating an innovative and cost-effective technology in the form of a backpack containing a small solar panel and necessary equipment for blood testing and ultrasound spot screening. The aim is to improve access to and quality of prenatal care in rural areas. Local nurses are trained to use the tools and perform a basic check-up to detect common obstetric complications. The information is stored in the computer offline and synchronized with a web platform when Internet connection is available.

In this way, the information can be reviewed by a specialist to confirm the diagnosis improving the nurses' training. It is estimated such tests could detect 80 percent of obstetric complications on time, at an average cost of USD 25 per pregnant woman (including two ultrasounds, two blood and two urine analyses). The aim is to convert an obstetric emergency—with expensive transfers and medical care which in many cases come too late—into a referral to an appropriate health center with a routine transfer one to two weeks before labor. First results from a sample of 1,000 women are very promising: health mortality has been reduced to zero and newborn mortality has decreased by 50 percent.[205]

Case 7.3: Uganda Health Information Network

The future of electronic health systems lies in unification and interoperability of different databases into a single database that contains not only electronic medical records but also vital registries. Efforts by the Uganda Health Information Network to unify information systems have delivered very promising results.[206]

A cost-effectiveness analysis showed that since 2003 the network delivered a 24 percent savings per unit of spending over traditional manual data collection and transmission approaches—a figure likely to increase as additional paper forms are converted.

District Health Services reported obtaining close to a 100 percent compliance rate on weekly disease surveillance reporting using the network, compared to the national average of 63 percent. The districts reported benefits including improved data quality at point of collection, more timely access to data for analysis and decision-making, and more rapid response to emerging situations.

Health workers at remote sites, even those with no fixed telephone lines or regular supply of electricity, routinely accessed critical information, including continuing medical education materials, which had previously been unavailable. They no longer had to travel long distances to district headquarters to deliver data or receive feedback, conserving time and resources for the health system.

In-country project partners not only acquired new staff and new technical and training capabilities, but also developed realistic strategic and business plans that forecast sustainability based on their ability to deliver connectivity, training and content on a fee-for-service basis to other NGOs, government agencies and institutions. An impact assessment indicated that consistent access to continuing professional development materials resulted in improved quality of health service to the local population.

Health workers provided improved clinical care to patients with malaria and diarrhea as a result of receiving health information broadcast through the network. They also referred to the literature available in their handheld devices, including national treatment guidelines, in their daily practices.

Over 50 percent of health workers surveyed rated handheld-accessed information useful at all stages of patient care, including diagnosis, treatment and advising patients on home-care. There was also increased health worker and client satisfaction with services provided at health facilities.

7.6. Training health providers

With growing populations requiring more healthcare, developed and developing countries face a gap in the number of trained, qualified health care professionals, especially physicians and nurses, over the next 15 years. In South Africa, for example, the number of doctors is just 0.6 per 1,000 people.[207] Providing sufficient training to a limited number of healthcare workers—often working in remote areas—is a significant challenge, but one that ICT is uniquely suited to address.

Telehealth and m-Health are changing the way healthcare workers get the training they need. Emocha, a platform created in 2008 by emocha Mobile Health Inc, allows frontline health workers in rural Uganda to select streaming video content as part of continuing health education.[208] The company also recently released 'TB Detect,' a free application for Android devices in the Google Play Store, allowing providers to access continually updated educational content about tuberculosis prevention, detection and care.[209]

Mobile devices are also optimizing communication and supporting frontline healthcare workers through multimedia training programs and clinical decision support tools. Social media is another powerful tool to educate and connect health workers but it is yet to be fully mobilized to support health workforce capacity-building. A number of benefits can result from enhanced use of social media—from crowd-sourcing of educational content, translations and localization (i.e. adaptation of content to a particular region), to peer-to-peer learning, joint problem-solving and reflective practice. In addition, ICT-enabled solutions can strengthen communication between providers and patients, increase community support for health worker capacity-building and heighten demand for high-quality clinical services.

To achieve SDG target 3.8 for universal health coverage, there is an urgent need for applications and tools to improve efficiency in resource management, especially among CHWs in rural areas where resource shortages are most acute. Often these tools are embedded within a number of mHealth ser-

Case 7.4: Empowering Community Health Workers[210]

Studies show that empowering community health workers (CHWs) with appropriate technologies can address primary healthcare needs in developing countries,[211] and improving the efficiency with which they perform health services can have large-scale effect. ICT-driven initiatives allow rural populations to be connected to otherwise inaccessible expert healthcare providers via equipped CHWs, increasing quality care and health outcomes at large. The challenge is to develop systems for CHWs that can scale with minimum additional personnel—and ICT can play a decisive role here.

Connecting health workers is one part of a joint, continent-wide 1 Million Health Workers campaign led by the Earth Institute and partners. The aim was to train, equip and deploy 1 million community healthcare workers throughout rural Sub-Saharan Africa by the end of 2015, reaching millions of underserved people.

Lessons learned

As one of the main partners, Ericsson laid the foundation for the campaign by providing connectivity to the Millennium Villages, along with more than 2,000 phones for CHWs to support mobile health applications and professional communication. Since the phones were first provided in 2007, mobility has had a particularly high impact on healthcare, leading to improved response times in emergency situations, reduced isolation, and better training and equipment.[212]

Mobile phone-based health services such as Open Medical Record System and ChildCount+, a platform specifically aimed at registering patients, monitoring nutrition, immunizations and other aspects of care, have shown that community health workers now deliver better-quality and more efficient healthcare services. By distributing mobile phones to the villages' community health care providers, children under five, pregnant women and newborns can now be monitored and patient records generated.

Within the 1Million Health Workers campaign, a unique data platform, Operations Room, provides an online inventory of CHW programs throughout the region to increase understanding of the programs and the people they serve, with the aim of advancing healthcare across the region. Operations Room enables data-driven decision-making by and concerning CHWs, filling a crucial gap—according to the WHO observatory, 14 countries in sub-Saharan Africa have missing data about CHWs, while Operation Room has counted 47,526 CHWs in 10 countries lacking data.

Use of ICT has also been found to increase job satisfaction among CHWs. A pilot smartphone app in Ghana, CNH on the Go has improved motivation and job satisfaction among frontline CHWs by combining virtual peer-to-peer support with improved connectedness to a professional network for community health officers, community health nurses and their supervisors.[213]

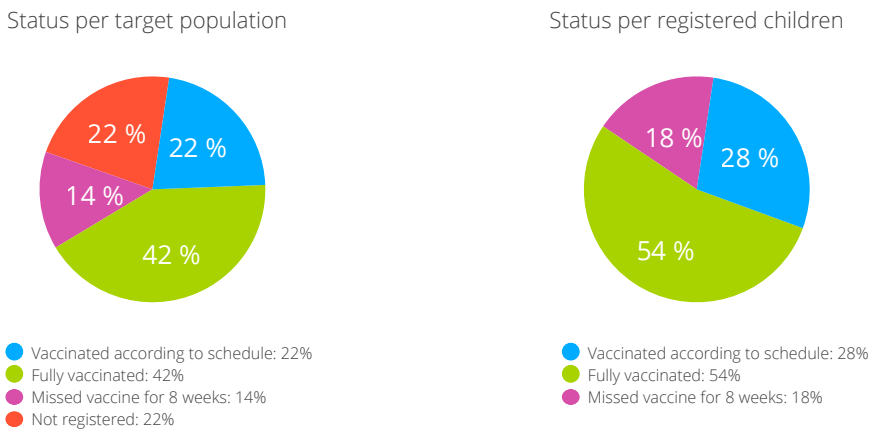
Case 7.5: Innovative app tracks child health indicators

Consisting of two interfaces—the MyChild App, which requires reliable network coverage/electricity, and the MyChild Card, which does not—SHIFO's MyChild system is artfully designed to address issues in preventative child health services in low-resource settings.

Lessons learned

With health centers in the Mukono and Wakiso districts of Uganda and upcoming implementation in the Mehterlam District of Afghanistan, the MyChild system has developed 63 indicators, including child growth and nutrition, maternal healthcare, and vaccinations, in order to identify key gaps in the regional health delivery system. The system creates an electronic health record for children under the age of five receiving preventative health services, thus allowing for necessary follow-ups on registered children. According to real-time indicators from the field, as of April 2016, 52,007 children had registered and 12,084 children had been fully immunized through the MyChild system. Figure 7.4 shows a MyChild report in Uganda that breaks down why certain children had not received a vaccine.

Figure 7.4. Child Health status



An example of MyChild reporting in Uganda showing reasons why certain children had not received a vaccine.

vice packages, such as Rwanda's mUbuzima, which helps supervisors monitor CHW performance and provide performance-based incentives as well as UNICEF's RapidSMS program in Rwanda, which enables supervisors to monitor exchange of SMS messages between CHWs and a central server to measure service accountability and responsiveness.[214]

Further ICT-enabled solutions that enhance CHW performance abilities include digitized scheduling functions of Txt-Alert as well as the MoTech 'Mobile Midwife Service' that alerts nurses to clients due or overdue for care to prevent missed appointments and delays in service provision.[215] Finally, using ICT-driven solutions for support at point-of-care can help ensure quality of care by reducing clinical errors—for example, Commcare's applications for smartphones at the Millennium Villages use accurate electronic checklists to improve CHWs' performance and time management.

7.7 Accountability: Drilling down to the numbers

A big challenge for the SDGs is to address the lack of data that made it difficult to track progress against the Millennium Development Goals to ensure existing initiatives can be monitored and evaluated.[219] Information and data processing enabled through ICT need to be available for all health initiatives related to the SDGs, not only to evaluate outcomes by 2030, but to constantly monitor the goals and take action when needed to address problems and policy constraints if desired milestones are not reached. Smart decision-making based on

Case 7.6: Making healthcare more efficient in Croatia with ICT[216]

Connecting 2,400 primary healthcare teams in the 20 counties and capital of Croatia, Zagreb, the Healthcare Networking Information System provides electronic reporting and booking, updates patient records, and digitalizes prescriptions and referrals, so they can be sent to pharmacies, hospitals and laboratories without the need for printouts.

Lessons learned

Ericsson worked with the government of Croatia to provide a solution to meet its aim of a more efficient health information system. The government found that that the e-health system met its aim of higher quality of healthcare in Croatia, health services made available to all citizens and better utilization of resources. Beside strict data security, the system offers real-time accessibility to top quality information for all users and it also achieved significant cost savings through dematerialization (for example, the e-prescription service can reduce paper consumption by 50 percent)[217] and makes more efficient use of human resources. A lifecycle assessment of the system conducted by Ericsson,[218] found that taken together, the e-referral and e-prescription services have the potential to reduce CO_2e emissions by up to 15,000 tonnes per year while the two services only add 330 tonnes of CO_2e/year from operation and manufacturing activities.

Case 7.7: Remote monitoring helps patients manage chronic conditions

An estimated 117 million people in the US have one or more chronic conditions, accounting for 75 percent of healthcare costs. This puts intense pressure on the national healthcare system both in human resources (exacerbated by a projected shortage of doctors by 2025) and costs[220] (21 million patients with diabetes in the US have USD 176 billion in direct medical costs). With aging baby boomers living longer, healthcare delivery is in dire need of a transformation. Remote patient monitoring has been shown to be an effective solution.

A remote patient monitoring platform launched by a large North American mobile operator is designed to care for patients in the comfort of their own homes. A cloud-based offering, it uses telemetry to remotely monitor patients with chronic diseases like congestive heart failure (CHF) and diabetes. The patients are provided a tablet that collects health data from device sensors via bluetooth and sends data to servers high-speed broadband connectivity. It also enables video calls between caregivers and patients.

Lessons learned

In two locations in Texas where the solution was piloted, the results were extremely positive. In one pilot[221] using remote patient monitoring, Texas Health Resources (THR) was able to lower CHF readmissions by 27 percent.[222] At most hospitals, CHF is the main reason for hospital readmissions[223] (typically one third of those cases). This is costly. Currently one in five patients are readmitted to the hospital within 30-days of discharge, at a cost of USD 14,000 (on average) per re-admission. THR's research arm, Texas Health Research and Education Institute, began in 2011 to monitor CHF patients remotely for 90 days after their hospital discharge.

In another pilot,[224] Christus Health, a healthcare system that includes more than 40 hospitals and facilities in seven US states, Chile and six states in Mexico,[225] used the AT&T Remote Patient Monitoring platform and experienced a significant return on the investment, including a decrease in average inpatient admissions from 1.31 to 0.25 post-program in the congestive heart failure patient population, with a large reduction in the average cost of care as a result, from USD 14,229 to USD 1,626. Patient satisfaction was also high, with 95 percent of the 45 patients in the initial pilot study extremely satisfied. That has continued to be the case as the program has expanded to a total of 140 patients. Patients' engagement with their care rose significantly, and they indicated that they felt healthier and experienced a greater connection to the care team at the hospital. They said they felt secure knowing that the software monitors their health at home but that at the touch of a button they can still talk to their nurses, and that the remote monitoring system means that their healthcare providers always have an overview into their state of health.

Incentives from payers and insurance companies and national health systems that support remote monitoring, and a shift to performance-based payment models have helped increased the rate of adoption. Close monitoring and engagement between patient and caregiver is effective with chronic conditions, as these can be effectively managed with diet, activity and medication. As the US and many other countries around the world face an unprecedented rise in non-communicable diseases, it is expected that the use of ICT in clinical tools that improve quality and efficiency of patient care will be leveraged across the entire health system.

high quality data benefits all the stakeholders involved. The SDG Target 17.18 calls for capacity-building support to developing countries by 2020, to increase significantly the availability of high-quality, timely and reliable data," in regards to achievement of the SDGs.[226]

Through these reports, the reasons for low vaccination rates can be detected, including variations in weeks, months or years to inform better policies for improving health outcomes.

7.8 Patient empowerment: Promoting best practices and health education

Patient empowerment through ICT tools can help achieve target 3.7 by ensuring universal access to sexual and reproductive healthcare services, including family planning awareness and the integration of reproductive health into national strategies and programs. Target 3.4 addressing nutrition to prevent obesity and heart disease can also be accelerated through ICT initiatives for patient empowerment.

Patient education and behavior change initiatives are delivering positive results for healthcare systems around the world. Such programs also promise to reduce costs and improve patient wellbeing. ICT can provide patients with information to stay healthier, through treatment compliance programs, nutrition programs, web health services, and direct communication with healthcare providers. It can also help patients with chronic diseases to attain greater control

over their conditions by helping with continuous monitoring and suggestions for treatment, improving patients' quality of life. One such innovation gaining popularity is remote monitoring (see case 7.7).

Remote patient monitoring allows for:

- A clinician to monitor at-risk patients' key vital signs at home preventing initial hospitalizations.
- Decrease in the rate of readmissions by detecting changes in health status earlier and accelerating interventions, improving the long-term health of the chronically ill and effectively managing costs.
- A caregiver to monitor the blood glucose readings and weight of diabetes patients to identify compliance and trends that could otherwise lead to complications.
- At-risk pregnancy patient to decrease the number of office visits while providing a regular stream of vital information to their obstetrician.
- Monitoring of "rising risk patients" that genetically or otherwise are prone to health issues.

7.9. ICT enhances disease surveillance, reporting and emergency and disaster response

Disease surveillance will be key for ending epidemics and managing national and global health risks to reach SDG 3 Targets 3.3 and 3.d. To strengthen national capacity for early warning and risk reduction of global health risks, and enhance timely, targeted medical response in the event of natural disasters and other emergencies, ICT is vital, given its

Case 7.8: Mobile phone data unlocks response to cholera epidemic[227]

In 2010 Haiti had an outbreak of cholera—the largest epidemic to strike a single country in recent history—right on the heels of the devastating earthquake which left hundreds of thousands of people homeless and on the move. Haiti had not endured a cholera outbreak for at least a hundred years. The population had no immunity and the health system had no previous experience of large-scale epidemics.

The team behind the Flowminder Foundation, an NGO based in Stockholm, with the mission of improving public health and welfare in low-and middle-income countries, established a collaboration with mobile operator Digicel Haiti, providing analyses to relief agencies on the distribution and movements of displaced people after the earthquake. Working with governments, inter-governmental organizations and NGOs, Flowminder collects, aggregates, integrates and analyzes anonymous mobile operator, satellite and household survey data.

Lessons learned

The Flowminder team provided analyses on the movements of anonymised mobile phones to all relief agencies, showing the areas in which large numbers of people were moving so the healthcare system could respond more effectively. An analysis of the project showed that mobile phone mobility patterns enabled prediction of the epidemic spread more accurately than standard models of population movement. As well as predicting risk of new outbreaks in an area, Flowminder's ensuing academic work showed that mobile data was correlated to the size of an ensuing outbreak—vital insight for strategic targeting of healthcare resources.

Such findings can help in preventing future spread of new pandemic strains of influenza or other emerging pathogens, crucial in stopping new strains during the first critical phase of an epidemic when the outbreak is still confined to a small area. To scale this method, resource-poor countries need support to establish basic but robust disease notification systems. Here again, ICT plays a vital role.

Following the Nepal earthquake 2015, Flowminder and mobile operator Ncell, the largest in the country, responded with a similar approach to population displacement[228] thanks to a rapid-response capacity set up to deal with earthquakes just a week before the quake struck. Flowminder used population data in combination with Ncell anonymized data from 12 million mobile phones in Nepal to quantify the impact of the earthquake on population movements.

The use of mobile communications data to support public health and response to disease outbreak, disease surveillance and reporting is becoming indispensable. In the case of the Haiti earthquake, the Flowminder team analyzed the movements of two million anonymous mobile phones, providing critical support to the UN and other relief agencies. The team subsequently showed in academic research[229] that these mobile phone movements corresponded closely to the real mobility of the population after the earthquake and that general population mobility before the earthquake could be used to predict post-earthquake population displacement patterns, providing a valuable opportunity to prepare relief activities before disasters strike.

capacity for real-time updates, data collection, reporting and data analytics.

Mobile communication is particularly important in infectious disease surveillance, since most infectious diseases spread through human movement. By integrating large numbers of data sources, including data from mobile phone operators, it is possible to model and predict spread of infectious diseases more effectively, without the limitations of latency, high cost and financial barriers to care typical of established sources. Crowdsourcing data allows researchers to gather data in near-real time, as people are diagnosed or even before diagnosis. Engaging people in infectious disease reporting also helps them become more aware of and involved in their own health.[230]

Case 7.8 shows how use of mobile phone data helped battle an outbreak of cholera in Haiti after the 2010 earthquake and assisted health workers and humanitarian organizations to respond to the Nepal earthquake in 2015.

Organizations have begun to use SMS as a method of infectious disease reporting and surveillance. After a 2009 earthquake in Sichuan province, China, when regular public health communication channels were damaged, the Chinese Center for Disease Control and Prevention distributed solar powered mobile phones[231] to local healthcare agencies in affected areas. The phones were pre-loaded with necessary software and one week after delivery, the number of reports being filed returned to pre-earthquake levels.

Unified SMS reporting systems have been recognized as indispensable in the Ebola and Zika virus crises. The mobile phone reporting platform, RapidPro, is an example of a cloud-based, multi-language platform launched by UNICEF and partners that pools SMS information from health providers on the ground, to help immediately monitor, track and counter the Ebola epidemic. Since its launch, over 20 million messages have been sent to/from beneficiaries in more than a dozen countries around the world.[232]

7.10. Issues and challenges

A concerted effort by countries is required to recognize and overcome key challenges towards achieving the health-related SDGs.

The MDGs made significant progress in addressing some major global health challenges, but there is still a great deal of work to be done, particularly in developing regions of the world. Maternal and child mortality, basic sanitation, HIV infections, and child under-nutrition continue to require serious attention.

Other challenges are currently being recognized as crucial to tackle in the SDG era, such as the lack of data on global health and the outcome of interventions. Without bridging the data gap, the tracking of existing initiatives and forthcoming disease epidemics will continue to vary in effectiveness. Given the increasing global migrations and movements of populations, diseases will continue to spread across the globe, and therefore robust ICT-enabled disease tracking systems are necessary to overcome this challenge.

Non-Communicable Diseases (NCDs) are growing in significance as a challenge for achieving the SDGs. As previously discussed, NCDs such as heart disease, cancer and diabetes accounting for two-thirds of deaths worldwide. Additionally, with more sedentary lifestyles becoming more prevalent in many societies, NCDs could pose an even larger challenge in the future.

Another persistent challenge is the lack of provision of quality health services in less developed regions, generally because of lack of infrastructure or government policy. Public-private partnerships can play a decisive role in improving provision of health services and medicines in these regions.

Linked to the above challenge is the issue of health management, which is important at all levels, whether public or private. In developing countries where proper infrastructure as well as human capacity to deliver health services is scarce, it is important for governments to create interconnected systems of health management. Special attention will need to be focused on rural areas, since health management decision-making generally occurs in urban areas.

Meeting the SDG on health will also require concerted attention to the issues of human resource capacity, poor infrastructure, mismanagement, disconnected health systems, and lack of efficiency. Finally, lowering the cost of healthcare in order to ensure universal health coverage will be a chief barrier to overcome. A fundamental shift in health financing, insurance provisions, and cost of health services will have to occur in order to provide universal health coverage. Leveraging ICT to improve efficiency within the health services supply chain and to lower costs will be fundamental in tackling this challenge.

7.11. Conclusions

The journey to achieving the health SDGs is fraught with many challenges for low-income and high-income countries, ranging from poor infrastructure to the prevalence of non-communicable diseases, as discussed above.

In this chapter, six mains ways were identified where ICT can play a crucial role to overcome those challenges and improve health outcomes. Those paths were increasing interconnectivity in the health system, upgrading quality of healthcare delivery, increasing access to quality data for accountability, ensuring cost-effective healthcare systems, and empowering patients. All of these paths will require the appropriate leveraging of ICT in innovative ways.

Certain ICT-enabled services such as telemedicine are becoming far more prevalent in developing and developed regions, and are helping to address the twin challenges of greater access to healthcare and lowering the cost of services. Other ICT-based initiatives, such as Electronic Health Records, are adopted in many developed countries, but are yet to be scaled in most developing countries. The majority of countries still have a long way to go in meeting the ambition of universal health coverage. Therefore, while each country has specific issues and pathways to achieve SDG 3, ICT can accelerate progress along the appropriate pathways.

7.12. Recommendations

SDG 3 calls for Universal Health Coverage (UHC) and rapid and deep progress on mortality reduction from a wide range of disease categories. These gains will depend on deploying the rapidly growing range of ICT applications in health care delivery.

(1) Unique ID for all patients (citizens) in the health system.

(2) Community Health Workers empowered by smartphone-based systems.

(3) E-health information system that seamlessly combines CHW reports, facilities-based services, and electronic medical records of patients.

(4) Remote diagnostics, consultations, image-reading, and other e-health telemedicine services.

(5) Remote-monitoring of patients through meters, sensors, medical treatments.

(6) Training of doctors through online instruction.

(7) Case management and training through online virtual meetings and classes.

(8) E-payments by government and the private sector for health personnel (e.g. salary payments).

(9) E-insurance and other e-financial services for risk protection.

(10) Emergency transport services online (e.g. phone-based call for ambulance services).

(11) E-coaching and e-mentoring of doctors and nurses in training.

(12) Real-time health dashboards based on CHW reports, facilities-based data, and vital events data (births, death).

(13) Online facilities inventory management systems.

8 ICT, Energy and Climate change

Embracing the Goals

SDG 7, to "ensure access to affordable, reliable, sustainable and modern energy for all," recognizes the crucial importance of universal access to sustainable energy and the de-carbonization of energy consumption. SDG 7 encompasses targets for universal energy access (target 7.1), renewable energy growth (target 7.2), energy efficiency improvements (target 7.3), international cooperation in sustainable energy infrastructure development (target 7.a), and technology upgrades and expansion of energy systems (target 7.b).

SDG target 7.1 recognizes that provision of energy access is critical for social and economic progress and calls for "universal access to affordable, reliable and modern energy services." Energy access enables services like powering medical equipment in hospitals, illuminating schools and businesses, cooking meals, turning on water pumps, powering computers and data centers, providing thermal comfort, and transporting people and goods around the world.

SDG 13 calls for taking urgent action to combat climate change and its impacts.

Facing the challenge

Access to energy is essential for human development and economic growth, yet over one billion people worldwide lack access to electricity—more than half in sub-Saharan Africa. As many as 2.8 billion do not have access to clean and safe cooking energy services,[233] and available alternatives such as kerosene and diesel have negative impacts on human health as well as the environment.[234] Not only do these energy access gaps need to be bridged, but it must be done in ways that minimize harm to human health, reduce global carbon emissions and help to combat climate change, in line with SDG 13.

The transportation sector in particular is a large consumer of energy, and accounts together with logistics for up to 40 percent of air pollution.[235] Transport infrastructure worldwide is under pressure due to rising population, environmental challenges and urbanization. By 2050, 7 out of 10 people will live in cities, which account for about 60 percent of global greenhouse gas emissions and 75 percent of global energy consumption, according to UN-Habitat.[236]

To address these challenges and achieve SDG7, easier access to affordable, cleaner, low-carbon energy sources is needed as well as major improvements in energy efficiency. ICT can

help to deliver both. Moreover, existing lack of infrastructure in many parts of Africa and Asia creates an opportunity for such regions to leapfrog—via innovative technologies such as ICT and renewable power generation—to achieve universal energy access by 2030 and for building the foundation for low-carbon cities of the future.

8.1. Introduction

Securing sustainable universal energy access is not only about making greater use of renewables, but achieving better energy efficiency and lower energy consumption in the services delivered to consumers. If the global population were to adopt the same energy consumption patterns as developed countries—a Business-As-Usual energy scenario—economic growth would be unsustainable. The amount of greenhouse gases (GHGs) generated threaten the climate as depicted in IPCC 6GS scenario237 and jeopardize achievement of SDG 13 to combat climate change.

An historic agreement to combat climate change and unleash actions and investment towards a low-carbon, resilient and sustainable future was agreed by 195 nations on December 12, 2015. The aim is to keep a global temperature rise this century well below 2 degrees Celsius. Scientists believe that a greater increase in temperature would be very dangerous. The agreement even establishes, for the first time, that we should be aiming for 1.5°C, to protect island states, which are the most threatened by the rise in sea levels.[238]

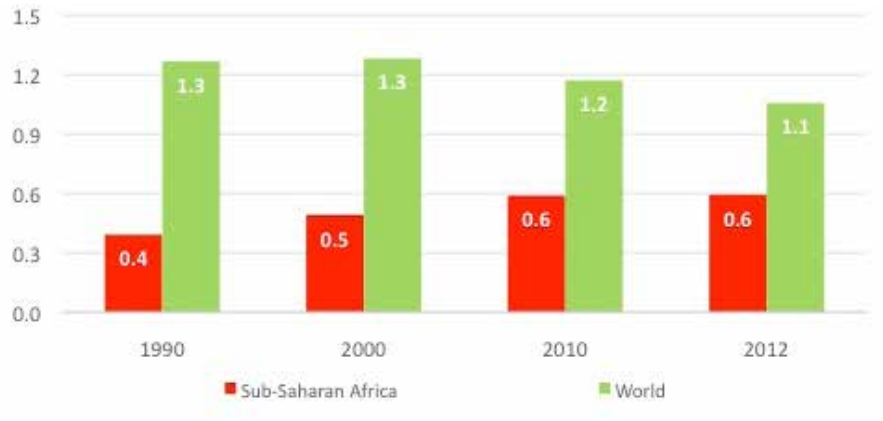
To provide energy sustainably to hundreds of millions of new users, address the cooking and heating needs of the world's least developed countries, ensure more efficient electricity delivery in developed markets, and support overall conversion to renewable power sources, harnessing new technology to deliver efficient, low-carbon solutions is crucial. ICT can help in three main ways—first, by catalyzing new business models for improving energy access and promoting uptake of renewables; second, by helping energy suppliers and other sectors to reap significant efficiency gains and manage consumer use; and third, by raising awareness and helping to drive the necessary behavior change to support a universal, low-carbon energy future.

Building new energy generation and distribution infrastructure would be cost-prohibitive. It would also impact achievement of other SDGs: cooking or heating with wood or coal, for example, is responsible for about 4 million premature deaths per year, undermining progress on SDG 3 on good health.[239]

SDG target 7.2 states that the world should "increase substantially the share of renewable energy in the global energy mix by 2030." With falling solar prices, wider-scale deployment is becoming a feasible substitute for high-carbon power sources. In addition to enabling new business models for provision of energy, ICT can help spur penetration of distributed renewable energy by allowing real-time measurement and control to help manage variables such as intermittent wind speed, solar irradiation and water flow.

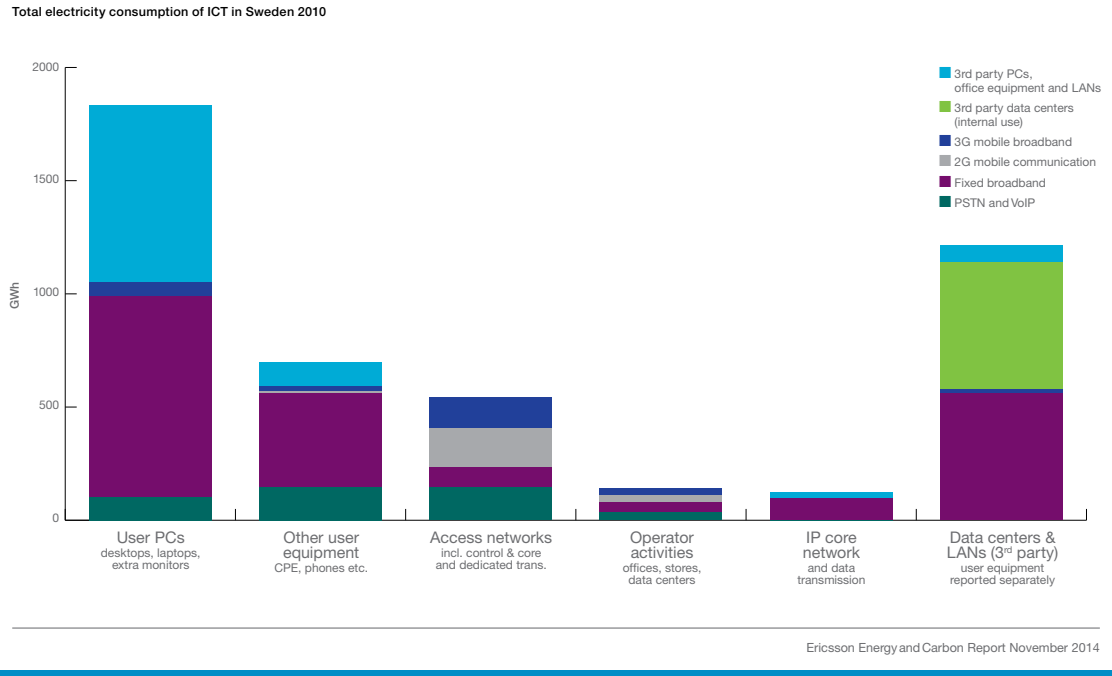
ICT can also play an important role in delivering SDG target 7.3, which sets out to "double the global rate of improvement in energy efficiency by 2030," yet at present some 70 percent of electricity is wasted before it reaches the end-user. This highlights enormous potential for ICT to make the whole electricity value chain 'smarter' and more efficient from extraction and production to distribution and use. As well as smarter operation of buildings, manufacturing facilities and

Figure 8.1. Number of people without access to electricity



Number of people without access to electricity and access to non-solid fuels.
Source: World Bank, Sustainable Energy for all (SE4ALL) database from WHO Global Household Energy database.

Case 8.1: Life-cyle impact of environmental impact of ICT[241]



In 2014, a national-level study of the lifecycle environmental impact of ICT was published with mobile operator TeliaSonera and KTH Royal Institute of Technology in Stockholm. This unique study was based on available statistical data from 2010. Results show that the ICT sector in Sweden consumed about 4,600 GWh of electricity in 2010. The main electricity-consuming categories were user PCs, data centers (servers) and other user equipment (customer premises equipment, CPE), as shown above. These areas also offer the largest potential for reducing electricity consumption.

The ICT sector comprises everything from end-user equipment to the access networks and data centers. The definition of 'ICT network' for this study included mobile and fixed-access networks (including broadband) to data transmission and the IP core network. User equipment was defined as everything from fixed and mobile phones to modems, computers and set-top boxes for IPTV. To provide a more complete picture, the enterprise networks as well as operators' own activities in terms of offices, stores, travel and vehicles were included. Lifecycle assessment data were collected for the vast majority of included products. The total GHG emissions of the ICT sector in Sweden amounted to approximately 1.5 Mtonnes CO_2ein 2010, corresponding to 1.2 percent of total Swedish GHG emissions.

appliances, growing connectivity between people, devices and the Internet-of-Things is paving the way for new paradigms in energy efficiency, as well as greater consumer awareness. Of course the ICT industry itself must also continuously improve its energy performance (see Case 8.1.).

Accelerating the shift to a low-carbon economy

Among the biggest contributions of ICT is its unique potential to enable other industrial sectors to reduce their environmental impact and improve sustainable urbanization. According to the Ericsson Mobility Report,[242] ICT solutions could help to reduce GHG emissions by up to 15 percent by 2030, amounting to around 10 gigatonnes of CO_2e—more than the current carbon footprint of the EU and US combined.

ICT solutions are applicable across all sectors of the economy, from transportation and logistics to buildings and utilities, where innovations such as smart metering and smart grid communications can enable higher levels of renewable electricity and reduced household energy consumption. In applications ranging from homes and commercial buildings to parking and lighting, digital transformation can support energy efficiency and CO_2 reduction through intelligent sensors

and controls that tailor energy consumption more precisely to demand. ICT also lowers operational costs and reduces complexity, making it easier for consumers to pay for energy and for utilities to receive payment.

ICT solutions could help to reduce GHG emissions by up to 15 percent by 2030, amounting to around 10 gigatonnes of CO_2e—more than the current carbon footprint of the EU and US combined.

Source: Ericsson Mobility Report, November 2015

Through ICT-enabled connectivity between commuters, logistics operators and transport infrastructure such as roads, rail and other public transport systems, more efficient traffic flows can help to ease congestion, avoiding the need for new transport infrastructure while providing efficient, safe and cost-effective transport of people and goods around the world.

Decoupling global GDP growth from energy consumption is key to achieving SDG 7 and its targets. The important role of ICT in ensuring sustainable and equitable access to energy was emphasized in 2011 in a UN initiative called Sustainable Energy for All (SE4All), launched to promote collaboration and partnership among governments, businesses and civil society. Emerging economies such as Russia, South Africa, China, Brazil have an opportunity to leapfrog to more sustainable energy development by drawing from successful initiatives in developed countries, increasing their energy intensity while at the same time spurring economic growth.

Monitoring energy consumption and energy efficiency, i.e., energy performance, is essential and it will be important to find new ways to measure progress, along with building greater societal awareness of the energy challenge to change habits and stimulate more efficient ways of using a scarce resource.

In short, to meet SDG 7, the energy sector must undergo a dramatic transformation in the way energy is delivered and utilized. Embracing ICT-enabled solutions can—and already is—playing a strong role in driving transformation of the energy sector and also supporting SDG 13.

Linkages to SDG 2, 6 and 11

SDG 2 which calls for ending hunger and includes areas such as increasing yield in agriculture and the whole food value chain, SDG 6 (Water and sanitation for all) and SDG 11, Sustainable cities and communities, are three additional SDGs which are closely connected to climate change. When parameters such as rate of evaporation vary a great deal globally, depending on temperature and relative humidity, distribution of precipitation in space and time is uneven, and therefore the amount of water available to replenish groundwater supplies will be impacted. Water and climate are also connected to the production of electricity from rivers and basins, among other water sources.

Cities are socio-economic powerhouses, generating over 80 percent of global GDP according to the World Bank. They also emit significant GHG emissions, rising from about 67 percent today to 74 percent by 2030 (International Energy Agency, 2008). If cities' investments include ICT then several SDG targets can be achieved simultaneously as outlined in a 2015 report by Ericsson and UN-Habitat,[243] "Information and Communication Technology for Urban Climate Action."

Sweden's Stockholm Royal Seaport, a sustainable urban district with the goal to be carbon neutral by 2030, is a prime example. It won the Sustainable Communities award in the C40 Cities Awards at COP 21. (Case 8.2)

8.2. ICT in action: Transforming the energy sector

Connectivity is transforming the energy sector. ICT delivers synergies across different technologies: sensing and control, automation of processes, energy storage, renewable energy generation, machine-to-human interactions, and efficient use of energy by consumers. Smart metering and smart grid communication are becoming essential for stability in the grid, particularly given the volatile nature of renewable energy sources, which benefit from greater measurement and communications in power networks than is typically needed with more predictable fossil fuel or nuclear power generation.

By using ICT to gather and act on information, smart grids give households greater control over their bills and environmental impact, and allow renewable energy sources to be better integrated into the power network. Real-time information enables providers to repair faults as they occur, and even to prevent them happening in the first place—hence addressing both SDG 7 and SDG 13.

This capability is already being demonstrated in today's 4G networks, and this will be enhanced by modern cellular networks that offer significantly higher throughput, lower laten-

Case 8.2: Energy-smart homes in Stockholm Royal Seaport

In 2015, a smart energy housing project with 150 new apartments was launched at the Stockholm Royal Seaport. Ericsson is part of a consortium of companies involved in the project, including Fortum, ABB, Electrolux and the Swedish Energy Agency and NCC, Erik Wallin and HEBA. The homes will be equipped with state-of-the-art energy technologies and connected appliances, so residents can monitor and control energy usage in real time. The aim is to develop smarter ways to use energy and reduce the total amount required.

Apartment residents will have much better overview of their energy use, while the companies will gain more knowledge about energy use in the building, which can help shape future development of smarter cities. The technology used in the apartments aims to make 'Demand Response' possible. Residents will visualize their electricity usage via a display alongside environmental and price signals and can allow the washing machine or tumble dryer to automatically run at a time of day when climate impact and/or price are lower. Residents will also receive a special electricity contract that supports this.

cy, and more data capacity compared to previous generations of mobile networks. This gives utilities more real-time control of their networks and meets the growing need to analyze data close to the collection point using private edge clouds.

8.3. New business models for energy access delivery

Multiple mini- grid installations around the world are successfully supplying rural communities with electricity from renewable or conventional power stations. These small energy systems usually include a generation site and connections to customers through a small electricity network. Mini-grid systems are important steps on the path to achieving SDG 7. The SE4All Global Tracking Framework 2015 estimates that half of the global rural population currently without energy access could be served with electricity via mini-grids.

Mini-grid encompasses micro-grids (grid systems with less than 10kW of power capacity) and mini-grids (grid systems with 10kW-100kW of grid capacity). Renewable energy is usually the power source of choice as it tends to be the most affordable energy option for remote areas that are unconnected. Declining solar energy costs are also making solar energy more affordable, fuelling exponential growth in solar energy deployment. In the last five years[244] the price of solar panels has fallen by as much as 80 percent.

A major requirement for sustainability of mini-grid projects is effective management of the mini-grid operation.[245] Depending on the business model for the mini-grid operation, costs related to building, operating and maintaining the mini-grid are shared among different stakeholders in the system. ICT can enable operators to monitor performance and identify and troubleshoot problems remotely, reducing operational and maintenance costs. With a network of smart meters, a knowledgeable organization, e.g system manufacturer, can remotely help local entrepreneurs to solve problems as they arise.

Making billing simpler

Innovative prepaid metering and mobile payment systems are dramatically lowering transaction costs of meter reading and bill collections, and bringing transparency to 'last-mile' utility operations—just one example of how mobile financial services are improving delivery of services in multiple sectors (see Chapter 5, ICT and Financial Inclusion).

A number of successful mini-grid projects use a variety of ICT tools to collect revenues. This includes smart meters, a metering device that not only measures electricity consumption but can also enable communications between the customer and the meter operator enabling data collection and control. In addition to smart meters, some systems also integrate mobile payments into their revenue collection systems.

Mobile payments through ICT are dematerializing the way people pay for energy services. As discussed in Chapter 5 on Financial Inclusion, the number of mobile payments has grown exponentially in many developing regions in the last five years. Although cash payments in collection booths or through rural agents are possible in many mini-grid systems, mobile payments offer mini-grid operators the additional efficiency and affordability that are key factors for the sustainability of their operations.

Cost-effective metering

Mini-grid operators working with remote, rural communities are lowering operational costs for revenue collection by using a metered and billing system that includes smart meters, such as prepaid or pay-as-you-go (PAYG) meters. While mini-grids are poised to provide 50 percent of new connections, individual off-grid systems or household wind turbines will account for 25 percent of new connections.[246] Providers such as Azuri Technologies, Brighterlite, M-Kopa Solar (see Case 7.2), Mobisol and Simpa Networks are providing rural electrification to dozens of remote communities across several countries in Africa and Asia using ICT-based pay-as-you-go (PAYG) revenue collection processes.

The pay-as-you-go model allows customers and companies to remotely operate and manage off-grid projects. For customers, it means avoiding a long trip to an agent or office to top-up their accounts. For companies, it eliminates the risk of cash vanishing along the supply chain and enables collection of installments without complex and costly operations. Mobisol acknowledges that ICT-based mobile money payments are what make the company's business model possible: without basic ICT infrastructure in place, their enterprise could not exist.

Diversified consumer base

One way to mitigate the operational risk of a mini-grid is to diversify its consumer base, while ideally retaining one main 'anchor' customer, such as a hotel, hospital, or school that provides semi-stable revenue to the operation.[248]

Cellphone coverage in rural areas is often far more extensive than electric service coverage. Of some 3 million mobile-phone towers in operation in Africa, about 640,000 are located in rural off-grid areas[249] and many of these have to generate their own power. Omnigrid Micropower Company (OMC) in India has developed a model that provides electricity services to rural communities by using mobile-phone towers as 'anchor' customers. An estimated 150,000 of India's mobile telephone towers are located in off-grid areas, or areas with unreliable electricity supply, showing significant potential to scale this model and accelerate rural access to energy.

8.4 Renewable energy in the grid

Renewable energy generation is key to providing clean electricity for the low-carbon economy.[250] However, the variable nature and current technology limitations of renewable energy are major barriers to increasing its share in the world's energy consumption mix. ICT can help overcome the challenges of integrating renewable energy sources into existing energy systems by assisting energy utility operators to actively manage the variability of renewable energy generation. With active management, a large number of renewable energy generators can be connected to the grid without major electric network investment.

Case 8.3: In Africa, pay as you go with M-Kopa Solar[247]

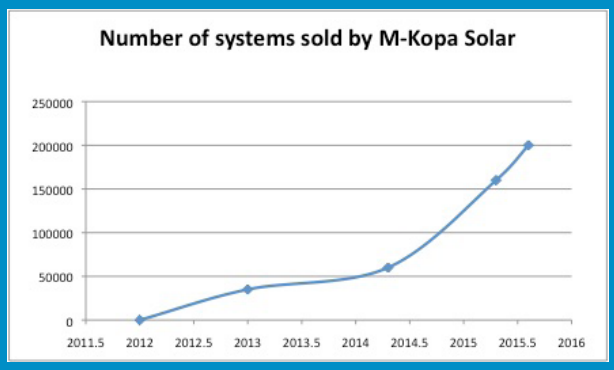
M-Kopa Solar is a successful Pay-As-You-Go (PAYG) energy provider in Africa. Commercially launched in 2012, it has sold more than 200,000 PAYG systems and sales are growing at a rate of 500 new systems a day.

Lessons learned

This success has been possible thanks to an ICT-enabled platform called M-KOPAnet.

M-Kopa systems have embedded GSM (Global System for Mobile) connectivity that enables them to collect revenues in real time through mobile money systems, monitor performance and regulate usage based on payments. The systems are affordable and small, with 8Wp (watt-peak), and can power three lights (two fixed and one portable), a mobile phone charger and a radio.

Figure 8.2. Number of homes connected with M-KOPA



Case 8.4: Affordable distributed energy in the UK

A pioneer installation of an ICT-based management system called Active Network Management started operations in 2009 in the Orkney Islands, UK. By 2012, 20 MW (megawatts) of renewable generation was connected to the island smart grid, with minimal electric network upgrades. The regional utility, Scottish and Southern Energy Power Distribution, estimated that an investment of GBP30 million would have been required to connect the 20 MW of energy.[251] The ICT-enabled solution cost just GBP0.5 million to implement. In 2013, the Orkney Islands started generating over 100 percent of their electricity through renewable resources. Currently, the renewable capacity installed is estimated to be over 55kW (kilowatts).

Whitelee Wind Farm (Renewable Energy in Scotland)

Creative Commons. https://commons.wikimedia.org/wiki/File:Whitelee_with_arran_in_the_background.jpg#filelinks

This successful application in the Orkney Islands is now being replicated by the utility operator, Scottish Power Energy Networks, with ARC (Accelerating Renewable Connections[252]) launched on the border between Scotland and England. The project uses ICT to collect data and identify areas with potential for more renewable connections. The UK was Europe's fastest-growing solar market in 2014, with significant further wind potential along the Scottish coast. The UK continues to works towards its Low Carbon Transition Plan to produce 30 percent of its electricity from renewable sources by 2020 and contribute to SDG target 7.2.

Although active management is enabled by ICT, the complete solution requires other policy inputs: Targets for renewable energy share, advanced commercial arrangements permitting reduction of power generation, enabling regulations in both the electricity and ICT spheres, and interoperability in the communications protocol so that operators can easily integrate their operations to the larger grid.

Enabling financing models for renewables

The previous section described how ICT can accelerate energy access growth and indirectly accelerate renewable energy penetration, since most mini-grids and off-grid projects include renewable energy generation. Renewable energy is becoming cost-competitive with other forms of electricity generation, especially in remote areas where constantly transporting fossil fuels is impractical.[253]

In the US and Europe, some companies offer solar photovoltaic generation equipment with no initial payment as long as customers commit to make payments over a 20-year agreement. These payments are lower than the cost of grid electricity replaced by the equipment. ICT monitoring of the system enables companies to monitor performance, meter the

service, analyze power demand and quickly respond to problems. As a result, people are reducing their electricity bills and enjoying better service.

New financing models will become available in developing country settings thanks to ICT-enabled solutions such as mobile money for collecting payments and the ability to monitor the system and counter non-payment through disabling a system. Some models are tailored to give ownership to users after enough payments have been collected, transforming traditional energy customers into independent small power producers.

8.5. Managing energy and tackling climate change

Recent trends in developed economies show that use of ICT has led to decreasing amounts of energy consumption per capita while GDP continued to grow, according to the OECD.[254] ICT is also key to building consumer awareness and enabling advanced methods for improving energy efficiency.

ICT is providing individuals and organizations with innovative ways to monitor their energy consumption and its related cost. Data can be collected at multiple points and displayed in different ways, through smart-phones, home displays, computers, etc. so users can make informed decisions about their energy consumption. Along with displaying energy usage, variable tariffs can also incentivize behavior change.

Indirectly, ICT can promote efficient use of energy by enabling mini-grid and off-grid solutions that improve the quality and efficiency of both energy services and products offered to people in poverty. A LED lamp is much more efficient than a kerosene lamp or incandescent bulb, for example. This extra efficiency translates into the poor having to pay less to cover the same lighting needs.

Monitoring consumption and building awareness

Among the benefits of smart meters is that online portals can be accessed by users via in-home displays, mobile devices or personal computers, increasing users' awareness of their own energy consumption patterns. Sharing energy consumption measurements and analysis with energy consumers can spur greater engagement on increasing energy efficiency.

A great example of how utilities can embrace innovation in data analytics is the success E.ON UK is enjoying due to Opower's web-based solution. It provides personalized information about energy consumption, neighborhood comparisons and tailored tips on how to control energy usage. Through this solution, the utility has improved its customer relationships tenfold.[255]

Governments are realizing the potential of smart meters and a number of European countries are targeting large-scale (80 percent or more) smart meter rollouts by 2020. This includes the UK, Sweden, Denmark, Finland, Spain, France, Italy, Germany and several countries in Central and Eastern Europe. To maximize success and effectiveness, the technology must be accompanied by the right policy framework, public education campaigns and incentives.

Smart metering deployments today are increasingly supporting richer services including connected home and smart building services. Utilities are offering incentives to customers that allow utilities to temporarily control air conditioners or lights to reduce demand peaks when the energy grid is stressed. An ICT-enabled infrastructure is fostering collaboration among stakeholders to increase overall system efficiency.

Real-time energy management for buildings

Adopting cost-effective standards for a wider range of technologies could, by 2030, reduce global projected electricity consumption by buildings and industry by 14 percent, avoiding construction of more than 1,000 mid-size power plants.[256] During the last decade, ICT has been able to track manufacturing processes, so operation managers can identify energy inefficiencies and where systems could be replaced or upgraded with more efficient ones.[257] For example, smart buildings feature interconnected building systems (e.g. lighting, ventilation, heating, cooling, etc), so these systems can be automatically or manually controlled to maximize energy efficiency while still providing a comfortable and productive environment for building occupants. Another benefit of interconnected devices is the enhanced preventive maintenance of equipment, which increases its lifecycle.

Availability of such solutions is not limited to developed countries. Azuri Technologies, a pioneer provider of small solar home systems in Africa, is now offering a Quad HomeSmart system for controlling appliances in Ghana, demonstrating that the technology can be tailored to developing country settings.

A scenario from IPCC 2014 suggests that the widespread implementation of state-of-the-art policies, building design and technologies, combined with behavior changes could deliver reductions in energy demand of over 50 percent from new and existing buildings compared to a Business-As-Usual (BAU) scenario. ICT-enabled remote control and management will be a key driver for achieving SDG target 7.3.

8.6. Government focus on the energy sector

ICT can improve decision-making processes for energy infra-

structure. Extending electric grids has historically been the main way to provide access to energy in China, India and Kenya, and remains an important way to provide access to unserved populations after mini-grids. Off-grid connections will also remain crucial for scarcely populated areas where a mini-grid would not be cost-effective.[258]

Electrification practitioners compare costs for different options to identify the optimal solution, and consider information such as distance of villages to existing grids, estimated electricity demand, cost of materials and fuels, cost of operation and maintenance, population density, geography and land ownership. Although the calculations and methodology for comparing electrification options are well-known, manually gathering the required data inputs without ICT support is impractical, particularly in remote areas of developing countries. Moreover performing the analysis and comparison of electrification strategies for thousands of households could take months or years, and can be prohibitive for many countries.

ICT can greatly assist governments, investors and utilities in the planning stage of energy infrastructure development. Innovative ICT and geospatial tools can reduce costs and time in gathering and mapping energy system infrastructure, such as the grid lines, electrical equipment, and demand points not available in existing national databases. Also, ICT can shrink the computational time from months to days by using cloud-computing when running analysis of thousands of data points of geospatial and demographic information (via census, GIS, land-use and other data derived from satellite remote sensing) to calculate accurate estimates of electricity demand.

Expanding access to ICT at regional and local levels can expedite the data collection and computational processes described above and can avoid travel between local offices and headquarters as well as enhance training of personnel at local level.

Enhancing transparency in energy subsidies

Governments provide different types of subsidy to boost initiatives that promote their economic or social policy. In the case of energy, these subsidies are created to increase energy access, energy security, and de-carbonization of the economy, because these benefits are not adequately reflected in free market prices. For example, subsidies for fuel and electricity for agricultural use aim to keep farmers competitive; subsidies for Liquefied Petroleum Gas (LPG) attempt to increase access to modern cooking fuels for poor customers; and subsidies for deployment of renewable energy are intended to achieve emissions reductions.

Governments, especially those in developing countries, have limited budgets that should be wisely and carefully administrated. Although subsidies usually have good intentions, implementation can be flawed and costly to taxpayers and can interfere with commercially sustainable business models. However, managed well, timely subsidies can help to scale and to re-direct investments, for example, as with electric vehicles, in Norway, or renewable energy for households in Germany and Sweden. Sometimes subsidies fail to help targeted beneficiaries due to subsidy leakage—where unscrupulous citizens receive the benefit of a subsidy without being legally entitled to it. ICT can help with the efficient distribution of subsidies by tracking and monitoring delivery. Governments can use ICT-tools to ensure that budgets allocated to improving energy access or efficiency actually serve this purpose.[259]

8.7 Tackling supply reliability and losses in the grid

A report by the Asian Development Bank (2009) shows that lack of reliable electricity supply was by far the most binding constraint to doing business in Nigeria for more than 80 percent of the firms surveyed.

The situation is improving: for example in Africa, virtually every country has legally mandated regulators to set minimum quality-of-service standards and monitor and enforce these standards.

ICT advanced solutions can match generation supply and demand and integrate variable renewable sources and energy storage systems to control costs and ensure grid reliability. In developed countries, outages are not frequent, and if they occur they are short in duration because customers support investment in grid quality and reliability with their willingness to pay.[260] Recent experience in smart-metered mini-grid operation has shown that even the poor are willing to pay cost-reflective tariffs for what they consume, if they are provided reliable electricity.[261] In less developed areas, reliable electricity is needed to support income-generating activities that can pull people out of poverty.

ICT-enabled smart-grids allow real-time data to be collected from different nodes of the grid by using computer-based remote control and automation to operate the overall system. The expansion of smart grids worldwide is influenced by a growing number of customers requesting affordable and reliable supply and by operators looking to lower operational costs. Governments are encouraging this trend and should also set up enabling regulatory environments, requirements for interoperability of devices and provision of universal ICT access so that the benefits are realized by the general population. Smartgrid.gov and smartgrid.eu are examples of this trend.[262]

Smart grids including e-transportation systems can allow for storage of electricity to balance the grid and reduce peaks.

Enforcing revenue collection

Losses that are not due to technical failure are a serious and costly source of revenue loss for electricity grid operators. This loss ranges from single digit percentage of total revenues in developed countries (2 percent in Texas, USA, 1.5 percent in Vancouver, BC) up to 50 percent in some developing regions (South Asia, sub-Saharan Africa, and the former Soviet Union).[263]

Every year in India alone, losses are estimated to be in the billions of dollars. The gas industry in Bangladesh is also prone to metering losses. Energy revenue lost from illegal connections, unbilled consumption, and non-payment is difficult to quantify, but due to its impact on energy access decisions, this loss should be curtailed. It prevents utilities and governments from expanding energy access infrastructure, due to the risk of energy pilferage, therefore it indirectly impacts achievement of SDG Target 7.1.

ICT can enable effective distribution by transforming the monitoring that helps locate theft and the technical losses within distribution grids.[264] In addition, smart meters and ICT can enable accurate metering of user demand. The Electricity Company of Ghana (EGC) instituted an automated meter reading program and has already installed 350,000 smart units in order to reduce losses through meter tampering in Ghana. The Ugandan utility UMEME used data concentrators to detect where the most non-technical energy losses were coming from, and this initiative saved them USD1.5 million within a year.[265]

8.8. Enhanced transportation with ICT

The transportation sector is a large consumer of energy; in 2014 the total share of US energy used for transportation was 28 percent.[266] Transport and logistics are responsible for up to 40 percent of air pollution, and regulation is being implemented to reduce transport's impact on CO_2 , NO_x and other emissions.[267] The transport infrastructure of many nations are now coming under significant pressures due to urbanization, rising global population and environmental challenges.

Energy efficiency improvement in the sector is not only coming from new engine and motor technologies, but also from the proper management of transportation assets. ICT use in transportation could increase energy efficiency (and therefore accelerate access), as well as reduce carbon emissions.

Reducing transport impact in cities

In the world's fast-growing cities in particular, solutions such as Intelligent Transport Systems (ITS) are vital. ITS integrates connected cars, public transport, and logistics operations, bringing greater safety, efficiency, and sustainability to roads and railways. The EU defines an ITS as a system in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.[268]

The manner in which transportation is 'delivered' needs to change. ICT plays both a fundamental and transformative role in the industry today. Use of technology may prove as effective as doubling or tripling the physical road capacity in some cities. Digital technologies, from modern control systems to sensor technologies, can create more capacity without requiring additional physical infrastructure.[269]

Autonomous vehicles

Autonomous cars or 'intelligent cars that assist drivers' can lead to dramatic reductions in vehicle weight and lower vehicle speeds without compromising time of travel in otherwise congested cities. This leads to greatly reduced energy consumption.[270] It also allows for greater human productivity and comfort, leading to higher economic benefits, and at the same time leverages scale-up of electric vehicles and reduces carbon emissions.

More efficiency throughout value chains

Such innovation would be impossible without the pervasive use of ICT that enables powerful sensing, computing and communications. Moreover the same level of consumer mobility experience can be provided through ICT with far fewer vehicles on the road. Service-based pay-per-use models for transportation could provide point-to-point transport (which is a similar experience to owning one's own car) without incurring the high costs of self-owned vehicles.

For developed countries, the link to transport and the links between home heating and power generation (energy transfer from power to heat or cooling) are increasingly becoming the focus of policymakers. Major CO_2 reductions are delivered when the economy can be dematerialized, e.g. by substituting services for products, or leapfrogging and changing entire value chains. Another example is to use renewable power within the transport sector, including charging of electric cars, and to heat and cool homes and buildings.

8.9. Issues and challenges

Ensuring that ICT can help the world move off the BAU path in enabling sustainable energy and achieving SDG 7 and SDG 13 by 2030, raises a number of issues and challenges, a few of which are addressed here.

Case 8.5. Connected buses in Curitiba, Brazil

The city of Curitiba in Brazil was the first in the world to connect public buses to a mobile-broadband network. A connected public-transport system makes for more efficient fuel usage and a corresponding reduction in CO_2e emissions.[271] Earlier studies on the bus system have shown that people will be attracted to public rather than private travel when provided with a more reliable bus service.

The Bus Rapid Transit (BRT) system adopted in Curitiba, which is used for 70 percent of all types of public and private commuting, produces approximately 200,000 tonnes of direct CO_2 emissions per year compared with 1,500,000 tonnes related to annual car travel in the city. The ICT portion of the BRT system adds about 500 tonnes of CO_2 emissions per year. This approach is now being implemented in Varna, Bulgaria (see Case 8.6.).

Case 8.6.: Integrated Urban Transport in Varna, Bulgaria

In January 2016, Varna, the third largest city in Bulgaria, launched an ambitious project for the modernization of its urban public transport system. It takes the success of Curitiba and evolves the approach to include traffic Management with traffic lights integration in order to provide priority to buses. This system supports better bus flow and speed with lower fuel consumption but also discourages the use of private cars in the city center.

The main objective of this project is the implementation of an Intelligent Transportation System (ITS) that fully supports the public bus operation, which includes 220 buses. The Varna ITS includes:

- An e-ticketing system.
- A system for automatic vehicle location.
- A real-time passenger information system.
- A traffic management system that provides priority to buses.
- A CCTV system at intersections and bus stops.
- Control rooms.

The ITS, being implemented by Ericsson, is designed to improve the quality and availability of transportation services; reduce traffic jams and increase the capacity and speed of public urban transport, while decreasing greenhouse gas emissions by optimizing bus routes. In addition, it will provide real-time financial management and control of ticketing revenue; the ability to offer new innovative ticketing plans and the safety of public transport.

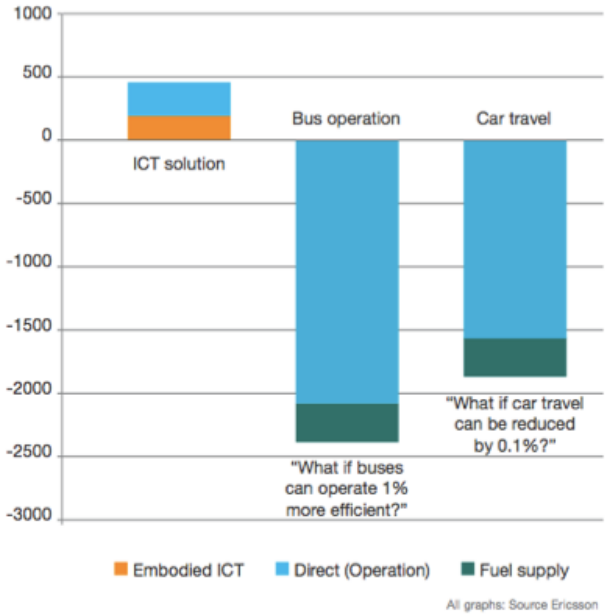
All the different elements of the transport ecosystem will be connected—vehicles and the supporting infrastructure, like roads, traffic lights and bus stops—through wireless sensors. The citizens of Varna who use mass urban public transport are expected to benefit in quality of life, including increased level of service, quality and accessibility of transport, including for people with disabilities. The estimated quantified benefits from a climate perspective are reduced emissions of greenhouse gases of 7,136 tonnes per year, the equivalent of 1,518 cars per year. This figure refers to the estimated benefits from the full implementation—including introduction of new Euro 6 buses.

1. **People-centered approach:** inclusion of ICT in energy systems should keep people and communities in mind. For example, remote controlled devices should involve people so they can make informed decisions about their energy consumption or at least access information when desired.

2. **Data privacy:** Measures must be taken to safeguard data privacy from smart meters to address emerging consumer concerns and meet European smart meter regulations. For example, the Trans-Atlantic Consumer Dialogue (TACD),[272] a coalition of consumer groups in Europe and North America, adopted a report on privacy and electrical services in Brussels in 2016. The Smart Meter White Paper[273] warns that the "dramatic increase in the granularity of data available and frequency of collection of household energy consumption means that the smallest detail of household life can be revealed."[274]

3. **Cybersecurity:** Solutions to strengthen cybersecurity measures are needed to ensure that the new interconnected energy infrastructure is not exposed to hackers. Malicious

Figure 8.3. Potential Saving from ICT, Curiba (tonnes CO_2e)



individuals can create blackouts if networks are not protected. Encryption and the use of dedicated communication protocols can reduce this risk. This concern is addressed further in Chapter 9, Issues and Challenges.

4. **Industry transformation:** To fully realize the potential of ICT in the area of energy and climate requires industry transformation to a low-carbon economy, including infrastructure for electric vehicles and addressing shifts in the value chain to facilitate dematerialization as well as taking into account urban and rural transportation realities. Finally, industry transformation requires an enabling platform for new business models to thrive.

8.10 Conclusions

Our energy systems are rapidly evolving, driven in large part by the inclusion of ICT to enable improved monitoring, control and management of these systems through the dramatic cost reduction of distributed renewable energy generation systems. As a result, new and alternative energy services are becoming more affordable, efficient, reliable and sustainable. This energy revolution is creating green tech jobs, promoting economic growth, reducing greenhouse gas emissions, fostering economic growth, enabling sustainable urbanization and improving energy security for countries that lack domestic fossil fuel resources. However, this revolution is not occurring evenly around the world due to differences in income, policy, ICT availability and human capacity.

The inclusion of ICT in energy systems can accelerate the rate of access to affordable, sustainable and modern energy services for people in different parts of the world. ICT is already helping to modernize electricity grids by increasing grid efficiency, cost effectiveness and integrating feed-in renewable energy resources. Other demonstrated advantages of using ICT in energy systems include improving energy subsidy distribution, enabling financing of clean energy technology and reducing the cost of revenue for energy services With an appropriate mix of programs and policy recommendations, ICT-enabled energy services can be scaled to achieve the SDGs. After the UNFCC Paris climate meeting, it is also time for action. The implementation of ICT as a technology to reduce GHGs is vital.

8.11 Recommendations

SDG 7 calls for universal coverage of modern energy services (electricity and clean cooking fuels) and major gains in energy efficiency. SDG 13 calls for the decarbonization of national energy systems as well as for change throughout value chains. For both goals, ICT will be vital for success, supporting the technical and business backbone of a clean-energy system. Key measures include:

(1) Promotion of mini-grid and off-grid solutions through private entrepreneurship. New companies will benefit from cloud-based monitoring, cashless payments, and prepayment business models.

(2) Detailed planning of coverage, costs, and reliability for incorporating intermittent renewable energy into low-cost energy systems.

(3) Minimum standards on electricity supply for grid operators to facilitate basic standards of service for renewable providers.

(4) ICT-based training and education for personnel in e-Energy services.

(5) Online tools to help households manage their electricity usage.

(6) Monitoring and managing of energy consumption through smart metering and the Internet of Things.

(7) Smart grid solutions as a fundamental building block for the low-carbon economies of the future.

(8) Secure that national targets on climate change and energy performance are matched with National Broadband Plans and set to support urban and rural implementation.

9 Issues and Challenges

The role of ICT in the SDG era (2016-2030) will evolve rapidly for two reasons. First, ICT will increasingly transform society, including governments, industry, institutions and organizations, and civil society. It will also affect the provision of every type of public service. Second, the underlying technologies themselves will continue to evolve swiftly, making way for breakthrough capabilities. Four issues in particular demonstrate the possibilities presented by new technologies:

Internet of Things (IoT): there are already 400 million cellular IoT subscriptions, forecast to reach some 28 billion connected devices worldwide by 2021.[275] The IoT will be a rich platform for innovation and is projected to add around USD 11 trillion of market value globally by 2025[276] across applications such as anomaly detection and control of complex equipment and integrated systems; systems optimization; prediction; data capture and analytics; and systems maintenance.

Automation and innovation: Next-generation mobile broadband (5G), IoT, artificial intelligence, advanced robotics and 3D printing herald unprecedented advances in healthcare, education, energy services, production, agriculture, and environmental monitoring and protection. But such innovations also raise issues such as privacy and security around protecting the integrity of individual data, and new areas of concern are likely to come to light as technology evolves.

'Big data' and analytics: through big data, it will be possible to produce in real time high-quality vital statistics (births, deaths, population), indicators for health (e.g. epidemic outbreaks), education (e.g. learning outcomes) and the environment (e.g. air and water quality). Both public and private sectors are making use of big data analytics and any risks must be balanced against the benefits to society, including the possibility to use big data for social good, such as improving response to disease outbreaks. A core part of any nation's ICT strategy should therefore be upgraded information platforms to harness the flow of big data in the service of public policy.

Advanced robotics: an industrial robot 'revolution' is already transforming many industrial and service sectors, with countries like China investing heavily in the R&D and deployment of advanced robotics and a surge in applications. Machine learning algorithms are enabling breakthroughs in robotics pattern recognition, voice recognition, natural language capabilities, and problem-solving capacities. Robots will be increasingly be used in the high-tech service economy in legal analysis, medical diagnostics, and other areas of complex problem solving.

Against this backdrop of rapid technological change, it is important that any possible downsides and risks that could arise through digital transformation are addressed and man-

aged and that supporting policies reflect ICT's exponential uptake. By tying ICT to strong social purpose, proactively mitigating issues and dealing effectively with threats, this technology's enormous potential for good can be maximized.

Possible concerns

A number of broad areas of concern have been identified which governments, industry and other stakeholders must work together to address:

1. **Privacy and surveillance:** The pervasive nature of ICT could result in loss of privacy, growth of surveillance and violations of human rights without adequate oversight and boundaries.

2. **Cyber-security:** A networked economy is more vulnerable to systemic network failures of the Internet or power grid, which could bring the economy to a grinding halt. Disrupting the networked economy could become the focus of deliberate acts of cyber-warfare and terrorism.

3. **Loss of human skills:** The online world will literally reshape brain development, possibly engendering loss of 'human' skills and the 'crowding out' of real communities, undermining social interaction and trust.

4. **Possible public concern about health effects:** To protect human health, radio wave exposure levels from products and network solutions must be kept within established safety limits, while sedentary lifestyles could contribute to the growing global burden of Non-Communicable Diseases (NCDs).

5. **Electronic waste and carbon emissions:** Growth in global ownership of digital devices, rapid product turnover and inadequate waste processing have led to accumulation of dangerous electronic waste; and while ICT can reduce carbon emissions in other sectors, it must also reduce it own emissions, focusing on energy performance.

6. **Digital exclusion:** As well as winners there will be losers from digital transformation—due to age and generation gaps, digital literacy, geography and industry sector. Ensuring no one is left behind is easier said than done.

7. **Child protection and responsible use of the Internet:** Using the Internet provides children worldwide with opportunities but also risks. The ICT industry has a role to play in protecting child safety in the online world including child sexual abuse.

1. Privacy and surveillance

Privacy is fundamental for building trust in the Networked Society. It is recognized as a fundamental human right by the United Nations in Article 12 of the Universal Declaration of Human Rights and other UN conventions. ICT has the potential to positively transform how we innovate, collaborate and socialize, but only if networks and services keep information secure and protect the universal right to privacy and freedom of expression.

ICT and the right to privacy are increasingly in the spotlight due to the exceptional growth in volume of personal data being handled by different entities, and the threat of potential breach and misuse of this data. According to the Ericsson ConsumerLab report, 69 percent of smartphone users share and view more personal content than two years ago, and one in two say protecting personal information should be a priority on the political agenda.[277]

Data security is therefore a top concern. As well as clear guidance on good corporate conduct and due diligence on human rights, appropriate limits must be set for government control of communication services, with effective oversight of laws on the interception and surveillance of data to preserve public safety and national security interests (lawful interception). Securing privacy in a connected world requires a sustained cross-industry effort with continuous dialog between industry, governments, regulators and civil society. The OECD Recommendation on Internet Policy Making Principles aims to strike the right balance between effective regulation and preserving the openness of the Internet.[278]

2. Cybersecurity

As well as protecting the privacy and safety of individual users, it is vital that potential threats to national security and industrial competitiveness are minimized. The number of cyberattacks around the world is rising, ranging from full-scale nation-state commercial espionage and state-sponsored hacking through to malware, ransomware, identity theft or phishing, and scams. With increasing numbers of connected people and devices, cybersecurity threats are multiplying, with significant risks that data stored in the cloud may be compromised or critical infrastructure like utilities, logistics and telecommunications hacked.[279] Underlining the seriousness of this threat, the US government has budgeted some USD 14 billion for cybersecurity for the 2016 fiscal year.[280]

These developments are exciting, but carry with them some degree of social and economic disruption as society adapts: ICT is already causing shifts in income distribution in high-income labor markets, for example, towards those with higher education in management (ability to lead complex organiza-

tions and systems) and STEM (science, technology, engineering and mathematics). Advances in robotics and smart systems are also likely to displace certain occupations, particularly for workers without tertiary qualifications and social policy will need to address this.

3. Loss of human skills

Questions are being posed over the long-term impacts of ICT on human behavior and development—particularly among children and teenagers who spend much of their free time gaming or surfing the Internet. Research suggests this may not only affect their social development and schoolwork, but may result in structural and functional changes in the brain in the regions that involve executive attention, decisionmaking, emotional processing, and cognitive control.[281] New conditions like 'Internet addiction' are now being treated as clinical disorders in China[282] and there is concern that children are losing interest in reading or going outside. Striking a balance between digital and real-life play is crucial.[283]

4.Possible public concern about health effects

In addition to the challenge of hazardous e-waste (see 5, below), concerns have been raised over possible health effects of electromagnetic fields and the sedentary lifestyles associated with digital activity. Reduced physical activity can lead to health problems such as obesity, heart disease and diabetes, and while many countries have workplace regulations to prevent problems such as repetitive strain injury or eyestrain, lack of physical exercise is rarely addressed as a specific health hazard.[284]

To ensure that radio wave exposure levels from products and network solutions are below established safety limits, rigid product testing and installation procedures must be observed. In particular for employees who work in environments where general public exposure limits may be exceeded and occupational exposure limits and compliance procedures need to be applied, e.g. near transmitting radio base station antennas or in certain laboratories, special training and awareness is required.

5. Electronic waste, energy performance and carbon emissions

Around the world, electronic waste—or e-waste—is growing exponentially due to increasing consumer demand, high product turnover and falling prices. Safe and easy disposal and effective resource recovery of old electrical devices have proved a challenge. In addition, e-waste can end up via illegal shipments in informal processing centers in low-income countries without adequate health and safety standards, raising concerns for both human health and the environment in recipient countries.

Step (Solving the E-Waste Problem) is an international initiative comprising manufacturers, recyclers, academics, governments and other organizations committed to solving the world's e-waste problem. With the ultimate goal of eliminating e-waste, Step shares information and implements solutions in the following areas:

- Reducing the materials used in manufacturing,
- Reusing equipment or components where practical,
- Refurbishing where possible,
- Recovering materials from obsolete equipment; and
- Recycling the highest possible level of materials.[285]

By working together and employing the principles of the Circular Economy, the problem of e-waste can be resolved.

Today, the ICT sector's share of global GHG emissions is around 1.6 percent and it is estimated to account for around 2 percent by 2020. This share is expected to have increased only marginally by 2030.[286] The industry therefore needs to manage its own energy performance through better network efficiency, new techniques and technologies, and greater use of renewables.[287]

6. Digital Exclusion

To ensure the benefits of the Networked Society are equally shared, it is crucial that special consideration is given to vulnerable groups, such as the elderly, those in remote communities where connectivity is poor as well as those who lack digital skills. Certain 'bricks and mortar' businesses may also suffer as trade migrates online and services are automated. These groups may need additional support and capacity-building to ensure digital inclusion.

In addition to raising digital literacy, further challenges that will need to be tackled include increasing mobile telephony penetration in poor countries, and reducing access costs. Affordability and accessibility are currently significant obstacles to the acquisition and use of mobile phones and are a key issue to resolve if, for example, the SDGs related to financial inclusion are to be achieved.[288]

7. Child protection and responsible use of the Internet

As a more vulnerable population, children require specific attention to ensure safety online, including issues such as child sexual abuse and cyberbullying. Initiatives such as the Global Child Forum[289] are platforms for informed, global dialogue and partnerships between different sectors of society to inspire cross-sector action on children's rights. The ICT industry takes action against child sexual abuse (CSA) online in a variety of ways, including designing tools which identify images verified by law enforcement authorities as CSA images. Child Online Protection Guidelines,[290] a multi-stakeholder initiative, also promotes awareness and develops practical tools for governments, industry and educators regarding child safety in the online world.

Alongside every breakthrough made possible by ICT, we therefore need to actively identify and manage the risks that accompany rapid development of the Networked Society. With appropriate public policies and strong multi-stakeholder commitment to a safe, dynamic, open Internet, the global potential of ICT as an accelerator can be realized.

10 Conclusions

The SDGs represent a complex, global-scale problem-solving exercise that cuts across all sectors of the economy and engages every country and region of the world. The world has adopted the SDGs: we must now deploy all tools available—especially the accelerated uptake of ICT—to act on our commitment and deliver on the SDGs for the benefit of present and future generations.

Hurdles remain

As well as outlining the incredible potential of ICT to drive disruptive progress against the goals, this report showcases the many practical barriers that remain to effective large-scale implementation of e-health, m-health, mobile commerce, e-education, smart energy and transportation services, reducing carbon emissions fighting climate change and connecting the unconnected. Digital transformation also addresses several other SDGs, as demonstrated throughout this report, such as access to a clean and sustainable water supply, ending hunger, achieving food security, improved nutrition and sustainable agriculture, and creating smart, sustainable cities.

Among the hurdles we need to overcome are that:

- Public sector policy frameworks and regulations do not currently enable full utilization of ICT.
- Mobile broadband physical infrastructure needs rapid expansion and upgrading in order to bring the 4 billion people that do not have access to the Internet online,[287] especially to public facilities like schools and clinics.
- More public-private partnerships are needed to leverage the solutions, scale and resources that the private sector can bring to sustainable development challenges, as well as to stimulate innovation and growth among SMEs, for example, incubate new ICT start-ups to provide locally appropriate services.
- Many ICT success cases exist, but there are still too many small, fragmented demonstration projects that require national scale-up and where business models need to address urban and rural realities.
- ICT-based system components need to be interoperable across multiple platforms in order to achieve scale.
- Significant training of personnel is required to manage ICT systems.
- Policy and regulation must play catch-up with rapid ICT innovation and deployment to ensure that new challenges, risks and threats are effectively managed.

It is vital that governments, academic and other institutions, business and citizens in developing and developed countries prepare themselves for this ICT-enabled transformation.

Bridging the gap

Many governments still have a long way to go to achieve even the first step of ensuring broadband coverage of all public facilities. Many governments remain at least two or three technology cycles behind the technology frontier in mobile broadband, e.g. deploying CHWs without ICT support, or relying on cellphones rather than smartphones in service delivery and data capture. Awareness of the promise of ICT in improving public-sector service delivery remains limited. Small-scale ICT demonstration projects often fail to scale up or become interoperable with other projects. And donor and UN agencies also have ground to make up in leveraging the potential of ICT for human development.

To realize the potential of ICT for delivering progress on the SDGs, it is vital that governments, academic and other institutions, business and citizens in developing and developed countries prepare themselves for this ICT-enabled transformation: many are not ready today. The UN Broadband Commission for Sustainable Development estimates that 148 governments had national broadband plans or digital agendas by mid-2015. Yet too few have adequately integrated their existing investments in ICT with their sustainable development agendas, and thus are not fully leveraging the potential of ICT.

In this, governments and policymakers have a special responsibility to ensure that key public–sector agencies, institutions and policy frameworks are reformed to support ICT-enabled transformation. Core government processes—payment, tax collection, procurement, training, human resources, program design, public deliberation, information management, analytics, legislative drafting, even voting—should be upgraded with the transformative capability of ICT in focus.

To leverage ICT effectively to achieve the SDGs by the target date of 2030, a number of things need to be put in place. For technology and innovation to deliver transformational change at the pace and scale required, three key supporting aspects need to align—an enabling policy framework, strong Public-Private Partnerships (PPP) and sufficient public and private investment.

Governments must start by mapping current realities and pace of change against the SDGs. They will find, with few exceptions, that the Business-as-Usual path is insufficient to achieve the SDGs by 2030 in both urban and rural areas. A back-casting process can then be used to determine what is needed to bridge the gap.

Universally this will require rapid acceleration of public investment and services in key areas—especially health, education and both urban and rural infrastructure. This is where ICT comes in: timely deployment can ensure faster technology upgrading and wide-scale access to quality training and service provision at low cost. With 2030 targets looming, this transition must be fast: we simply do not have the luxury of cautious, incremental uptake of new approaches.

Six key areas for action

To kickstart ICT-enabled transformation and realize its benefits, policymakers need to take a broader, more coherent ICT policymaking approach. In line with the recommendations set out in Chapter 11, there are seven key areas where governments can act to trigger ICT-enabled transformation of the economy:

1. **Broadband by 2020:** Establish a timeline for universal broadband connectivity of public facilities and services—no later than 2020. ICT infrastructure, especially mobile broadband, needs to be urgently put in place in all regions, across the public sector. Clinics, hospitals, schools, universities, infrastructure networks and public administration should be connected to a high-speed broadband network by 2020. If basic infrastructure is delayed, the 2030 SDG targets will become impossible to achieve. With the right incentives and enabling environment, private-sector operators will engage to finance much of the needed infrastructure with business models addressing both urban and rural realities. No industry has scaled like the mobile industry, where fair competition, global standards and economies of scale have driven down prices, secured inflow of capital and improved accessibility.

2. **Enabling policy framework:** Adopt the 10 recommendations for multi-stakeholder action from the UN Broadband Commission Task Force on Sustainable Development[291] and develop enabling policies that address the supply- and demand-side issues identified in the box below while protecting the right to privacy and freedom of speech. Government policies must allocate spectrum; support and facilitate right-of-way for the fiber backbone; allow easy entry of ICT-based companies into the economy even where existing business models and practices are disrupted; and ensure public administration is ICT-ready. Strong commitment to the vision of a Networked Society is also essential to facilitate rapid acceptance and diffusion of ICT-backed systems.

3. **Rapid ICT rollout:** Drive integration of ICT throughout the public sector—across governance, public administration, and provision of public services including health, education and infrastructure. E-governance and online delivery of ICT-enabled public services like payments, transfers, tax administration, vital registrations and documents, etc, will lower the cost of public services, reduce opportunities for corruption and create a flow of big data that can be collected, processed and analyzed to improve public service delivery and support evidence-based policymaking.

4. **Public-Private Partnerships (PPP):** New partnerships that are solutions oriented are needed between government, international organizations and industry in order to find sustainable business models that support wide-scale ICT deployment. For example, to connect the unconnected in areas that are not currently profitable, or to accelerate the creation of innovation hubs (see 5), sufficient public and private investment needs to be actively targeted towards ICT.

5. **Accelerate the creation of innovation hubs to develop new ICT applications**—especially locally designed and targeted ones. National policies should encourage ICT industries, both local and international, to operate within the country to provide solutions and apps designed for the local context. To facilitate rapid diffusion of ICT-based solutions, governments should work actively with ICT companies to achieve the SDGs through PPPs.

6. **Upgrade STEM:** Foster science, technology, engineering and mathematics skills in primary and secondary education to build long-term technology readiness and scale up

Policymaking for ICT deployment

Supply-side ICT policy issues

- National broadband policies
- Network regulation
- Spectrum management

Demand-side ICT policy issues

- Industrial Internet/ Internet of things
- Media/content regulation
- Data protection

Horizontal policies impacting supply and demand side

- Internet governance
- Trade policies
- Intellectual Property Rights (IPR)

Emerging policies impacting supply and/or demand side

- Critical infrastructure and cybersecurity
- Data-driven innovation

ICT training programs with universities. Working with universities and ICT businesses, government must also ensure technical workers are equipped to write the apps and manage the infrastructure of new ICT systems and entrepreneurship skills are nurtured to spur new business development.

7. **Harness big data and analytics:** Create national online and open databases using big data from public service provision and satellites, mobile networks, remote sensors and other connected devices in the Internet of Things. This real-time online data will be a critical resource for monitoring and evaluating the state of achievement of the SDGs, for forecasting different scenarios, and promoting investment by the private sector.

A broad, multi-stakeholder approach

Can national and local governments and other sectors of society prepare for and implement this rapid ICT-led advance? The answer is yes, provided there is a strong, shared vision of how to proceed and new ICT-supporting policies are quickly put in place. This requires unprecedented collaboration, as called for by SDG 17, between national governments and local authorities, the global ICT sector, universities, and global donors, including philanthropists and foundations.

The international ICT sector, represented for example by the UN Broadband Commission for Sustainable Development, will need to provide advice, expertise, financing and tools for rapid scale-up. ICT companies, both large and small, should endeavor to be good local citizens and commit to participate actively in local partnerships to achieve the SDGs in all host countries where they operate.

Cross sector integration of ICT is critical. All public and private firms should actively drive digital transformation in their respective sectors: construction companies, for example, should facilitate wired or wireless broadband in all buildings; transport and infrastructure firms should deploy ICT, including the Internet of Things (IoT), smart metering of infrastructure and remote sensing of environmental conditions.

Universities, in partnership with governments and businesses, will have to undertake massive training programs, and host new ICT business incubators. Universities and ICT businesses, working in cooperation with government, must deliver the appropriate training to prepare citizens for an ICT-centered future. The UN Sustainable Development Solutions Network, which includes hundreds of universities around the world, is already gearing up to support higher learning instutions to take on this ICT leadership role. Global donors will have to provide quick seed funding to get these activities underway and ensure a promising pipeline of scalable, evidence-based solutions.

Our 2030 legacy

The policy choices governments make today will have significant impact on R&D investment (knowledge creation), value creation (innovation), rollout (diffusion) and use (adoption) of ICT. They will determine the capacity of ICT to drive transformational change and deliver socio-economic benefit, both in the short and long term. They will also shape the ability of end-users (individuals, businesses and public services) to benefit from ICT and enjoy the inclusion and empowerment it brings. In short, by putting in place the right policies today, governments have an unprecedented opportunity to determine the success of the 2030 Agenda.

11 Recommendations

ICT, and especially mobile broadband, will be the essential infrastructure platform for the SDGs. Technological development of ICT is in line with earlier technology breakthroughs like steam engines, electricity and the combustion engine.

Paragraph 15 of the 2030 Agenda for Sustainable Development notes that ICT "has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies" and Target 9.c and 17.8 call on SDG partners to "significantly increase access to information and communications technology and to strive to provide universal and affordable access to the Internet in least developed countries by 2020."[292]

Building on the excellent recommendations already set out in the Broadband Commission report, 'Means of Transformation: Harnessing Broadband for the Post-2015 Development Agenda," to capture the power of ICT to deliver the SDGs by 2030, we recommend the following:

ICT for Development

The ICT Platform must be designed to support an expanding range of services and applications. Each country should adopt—no later than 2020—the following platform elements:

(1) National physical infrastructure for full connectivity to broadband throughout the country built on understanding the realities in urban and rural areas.

(2) Cyber infrastructure and policy frameworks that include a unique biometric ID, privacy rules, rules for the collection and dissemination of cloud data.

(3) Interoperability of the ID system, e-payments, e-governance tools (e.g. online registration, voting, receipt of public documents, transfers, tax payments, etc.).

(4) Close collaboration with local authorities, the private sector, universities and civil society in promoting the rapid uptake and improvement of ICT applications.

(5) Integration of information systems that support service delivery (e.g. schools, clinics, community health workers), facilities management, public budgeting, e-payments, policy dashboards, and SDG data reporting.

(6) Promotion of the Internet of Things, through extensive metering, monitoring, and remote sensing of physical infrastructure (e.g. power grids) and the environment.

(7) Integration of ICT applications in national strategies for each SDG (e.g. e-health, e-education, e-energy, etc) with ICT as a basic infrastructure.

(8) Partnership of national governments and private sector members on sustainable business models that can support rapid rollout of ICT national strategies, infrastructure and monitoring tools (such as ICT scorecards).

ICT and Financial Services

ICT will expand online banking and commercial transactions and support public-sector budgets and transfer payments. The 2030 Agenda sees financial inclusion (e.g. banking, payments, insurance and other risk protection, etc.) as vital for ending poverty (SDG 1) and hunger (SDG 2), and for delivering universal health coverage (SDG 3), gender equality (SDG 5), small businesses and entrepreneurship (SDG 8), sustainable infrastructure (SDG 9), and other goals. Key elements include:

(1) Unique online ID for all citizens

(2) Enabling environment so that mobile banking can be available to all citizens

(3) Use of e-payments by government for all public-sector transfers to households (paychecks, subsidies, reimbursements, salaries, etc).

(4) E-payments for taxes and other fees.

(5) Education programs for all students on e-payments, e-Identity, e-governance

(6) Public outreach campaign.

(7) Regulatory environment promoting e-payments by private companies.

(8) Regulatory environment promoting e-banking at the household level.

ICT and Education

SDG 4 calls for the dramatic scale-up of universal quality education from pre-K to secondary completion. This will be achievable only with intensive, innovative use of ICT for education, by 2020 or earlier. This must include:

(1) Connectivity of all institutions—primary, secondary and tertiary—to wireless broadband and video-link capacity.

(2) National teacher training in ICT equipment and applications.

(3) Development of new online curriculum in appropriate local languages at lower levels and national languages at higher levels.

(4) Training of teachers and students in ICT (computers, coding, ICT applications, etc) at all levels of schooling and development of online courses (MOOCs) for high-school and tertiary education, with accompanying print teaching materials.

(5) Creation of free, online libraries with e-books, e-journals and e-magazines for use in all low-income countries, and use of video-linked classrooms to extend the reach of the nation's best teachers and schools.

(6) Online monitoring of schools (teacher participation, student attendance, supplies and inventory management) including real-time, cloud-based policy dashboards for education managers covering school enrolments, attendance and performance, and online national testing of students at least once per year.

(7) E-payment of teacher salaries and other Ministry of Education outlays.

(8) Deployment of Community Education Workers (CEWs) akin to Community Health Workers (CHWs) to help schoolchildren in need.

(9) ICT technologies for special needs, including voice recognition, online Braille and others.

(10) Scholarships for students from developing countries, including "vocational and information and communications technology, technical, engineering and scientific programmes", as called for in Target 4.b.

ICT and Health

SDG 3 calls for Universal Health Coverage (UHC) and rapid and deep progress on mortality reduction from a wide range of disease categories. Gains will depend on deploying the rapidly growing range of ICT applications in healthcare delivery and putting in place the following:

(1) A unique ID for all patients (citizens) in the health system.

(2) Remote diagnostics, consultations, image-reading and other e-health telemedicine services, virtual case management and remote-monitoring of patients through meters and sensors (e.g. wearable technology).

(3) Training of doctors and other healthcare workers through online instruction, virtual meetings and classes, with e-coaching and e-mentoring.

(4) E-payment by government and the private sector for health personnel (e.g. salary payments) and e-insurance and other e-financial services for risk protection.

(5) Emergency transport services online such as mobile phone-based calls for ambulance services.

(6) Online facilities inventory management systems.

(7) For Community Health Workers (CHW), provision of smartphone-based systems and an e-health information system that seamlessly combines CHW reports, facilities-based services, and electronic medical records of patients. Additionally, real-time health dashboards based on CHW reports, facilities-based data, and vital events data (births and death).

ICT, Energy and Climate change

SDG 7 calls for universal coverage of modern energy services (electricity and clean cooking fuels) and major gains in energy efficiency. SDG 13 calls for the decarbonization of national energy systems. For both Goals ICT will be vital for success, providing the technical and business backbone of a clean-energy system. Key measures include:

(1) Promotion of mini-grid and off-grid solutions through private entrepreneurship using cloud-based monitoring, cashless payments, and prepayment business models.

(2) Detailed planning of coverage, costs and reliability for incorporating intermittent renewable energy into low-cost energy systems.

(3) Minimum standards on electricity supply for grid operators to facilitate basic standards of service for renewable providers.

(4) ICT-based training and education for personnel in e-Energy services.

(5) Online tools to help households manage electricity usage.

(6) Monitoring and managing of energy consumption through smart metering and the Internet of Things.

(7) Smart grid solutions as a fundamental building block for the low-carbon economies of the future.

8) Secure that national targets on climate change and energy performance are matched with National Broadband Plans and set to support urban and rural implementation.

ICT and Inclusion

Lastly, to address the digital divide and ensure that no-one is left behind by digital transformation, special consideration must be given to the last 300 million unconnected citizens (see Chapter 3). Many initiatives are ongoing to connect the unconnected, including the work of the Broadband Commission on Sustainable Development, The US Global Connect initiative, the World Economic Forum Internet for All, and the Alliance for Affordable Internet, to name a few. To go the last mile of digital inclusion, the following issues must be addressed to ensure that Internet connectivity will be more available, accessible, and affordable around the world:

(1) ICT should be part of all national development strategies and plans.

(2) Provision of adequate infrastructure—including MBB, roads, power, etc—including pushing the boundaries of mobile Internet through 3GPP, improving spectrum regulation, and leveraging innovative public-private partnerships.

(3) Public-private partnerships to incentivize the build out of connectivity in areas currently not profitable, and major lending institutions need to increase funding toward ICT as a key infrastructure for development

(4) Continued focus on global standards and economies of scale to continue to reduce, for example, the cost of devices. Proven mobile 3GPP technologies, global standards, harmonized spectrum are driving economies of scale and hence affordability, factors that constitute key supply-side ingredients for success.

(5) Target initiatives are needed to develop ICT literacy and skills, both human and organizational, with a focus on including women and youth.

(6) Demand stimulation and support for emerging eco-systems for local apps and content.

ICT and the SDGs

This report is a call to action. It highlights the need for strong, urgent government action and policy reform to leverage existing investments in broadband infrastructure to deliver on our shared sustainable development goals.

To keep track and measure the impact of ICT-driven technological transformation in support of the SDGs, new indicators will also be needed to evaluate productivity and growth, as GDP alone is not an adequate measure to capture ICT transformation. These indicators must also meet the principles for Global Monitoring Indicators proposed by the Sustainable Solutions Development Network (SDSN):

(1) Limited in number,

(2) Simple,

(3) Intuitive,

(4) Policy-relevant,

(5) Consensus-based,

(6) In line with international standards,

(7) Relevant to all; and

(8) Able to be aggregated.[293]

With these elements in place, making the shift from a BAU path to achieving the SDGs by 2030 is definitely possible.

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