FONDATION POUR LES ÉTUDES ET RECHERCHES SUR LE DÉVELOPPEMENT INTERNATIONAL

Chair "Digital Trust"

Digital for Development Research Initiative

The Use of Digital for Public Service Provision in Sub-Saharan Africa*

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* Revised version August 2022

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Friday, September 11, 2020.

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Executive summary

The objective of this report is to provide an in-depth review of the digitization of public service provision in Sub-Saharan Africa in general and West Africa in particular by highlighting both the opportunities and the challenges faced by digital initiatives multiplication in the region. The first section is an introduction with contextual information related to the need for digital solutions where market failures have created gaps in public services. The second section provides a general background explaining the mechanisms by which digital initiatives can improve public service delivery and paints a picture of the current state of digitization in the region. This first step is necessary to understand where SSA is starting from in terms of digitization, and what conditions are necessary for digital technologies to be able to spur the region to catch up in access to public services. In the third section, once the global picture of the information and communication technology (ICT)-public service nexus in Africa is given, the report goes into the details of selected digital initiatives by proposing a review of evidence-based analyses of African digital interventions that aims to unravel the reasons for their success or failure. The fourth section synthetizes the findings of the report and draws some policy implications.

Goldfarb and Tucker (2019) define digital technologies as "the representation of information in bits […] rather than atoms", which "reduces the cost of storage, computation and transmission of data". This definition depicts digital technologies as a type of ICTs with a strong cost-reduction potential. This capacity to reduce various types of cost – information, travel, tracking, and replications costs – makes digital technologies "enabling technologies" (Bresnahan & Trajtenberg, 1995), offering solutions when the provision of public services is undermined by market failures (Aker, 2017). Digital technologies have the potential to leapfrog infrastructures, processes, administrations, institutions that have been put in place and gradually evolved in industrialized countries to reduce market failures, but which are missing or failing in low-income countries. This potential, however, greatly depends on ICT adoption and diffusion throughout the population.

In SSA, populations excluded from public service provision are usually the same populations that are deprived from access to ICTs; consequently, ICT-based public service provision interventions which fail to account for the various dimensions of the digital divide may miss their intended target populations. In other words, such interventions, in order to maximize their development impact, should be designed to target rural populations located far from available broadband infrastructure networks, often characterized by limited literacy and numeracy rates and low average household income, and to address gender inequality. Moreover, despite the rapid uptake of mobile phones and the multiplication of digital innovations across the region, Internet provider network coverage is still limited compared to other developing areas. An environment more conducive to the adoption internet-related technologies could certainly improve the digital dividends for public service delivery, employment, economic diversification, and private sector development in economies of SSA (Ndulu, 2006; Schumann & Kende, 2013). However, interventions promoting digital public service provision through simple mobile phone use should benefit from a better adoption throughout the population, especially in rural areas.

The uptake of mobile phone technology has facilitated the multiplication of digital innovations throughout the region. In West Africa, this uptake of ICTs has enabled the implementation of more than 400 operational digital initiatives in 2019 (Briter Bridges, 2019) across a wide range of sectors and countries. Fintech, Ed-Tech, Health-tech, Agro-Tech, E-commerce and Job platforms represent the sectors most affected by the expansion of digital initiatives. However, only four countries – Nigeria, Ghana, Senegal and Côte d'Ivoire, in decreasing order – contain more than 75% of these initiatives. Therefore, the digital innovation process is unequally distributed throughout the region, mostly benefitting the four biggest economies of SSA.

Studies conducted in rural areas of Niger and Ghana confirm that the adoption of communication technologies like mobile phones can increase agricultural market efficiency through multiple mechanisms. For example, it can improve farmers' production and selling decisions, the coordination of input and output supply chains, and farmer bargaining power with traders as well as foster the adoption of efficient or innovative production technologies (Aker, 2011; Aker et al, 2016). However, as pointed out by Aker et al (2016), to be effective, ICT-based applications for the agricultural sector have to take into consideration various contextual factors. Such factors include the type of informational asymmetry incurred (price risk reduction, increased geographic extent of price information searches, information on agricultural techniques, etc.), the existence of market failures in related markets (e.g. insurance or credit markets), the type of crops cultivated and sold in markets, or the sociodemographic characteristics of farmers.

Moreover, ICTs will empower farmers vis-à-vis other market agents inasmuch they can provide them with trustworthy information. In a decentralized private information setting, the reliability of market information depends on the size of the farmer's information network, i.e. the number of information connections from which famers can extract information. In a centralized public information setting, including those promoted by agricultural extension programs such as a centralized Market Information System, the reliability of information seems to depend on ICT penetration but also on the degree of adherence to the extension program. Ultimately, mobile phone adoption by farmers can serve as a platform for electronic money storage and transfers (mobile money), thereby providing access to insurance and savings mechanisms, which is a critical step towards financial inclusion of unbanked farmers.

The implementation of digital technologies in the education sector, when intervention designs consider them as monitoring technologies, are found to enhance teacher performance and school administration efficiency. They have also demonstrated their effectiveness in e-learning adult education programs, more particularly when digital technologies are used as out-of-school learning-by-doing engines, whose basic communication functions (writing messages, making phone calls, making money transfers) can improve learners' numeracy and literacy skills. However, they stress the limited or mixed impact of e-learning initiatives for children, based on more sophisticated technologies such as computers or tablets, due to their low uptake in the population and the poor familiarization of intended beneficiaries with them. Some reasons for this include that these technologies are more expensive, more vulnerable to climatic conditions, and more prone to theft. The resulting low uptake in the population therefore represents a critical constraint for the scaling up of such initiatives, where they have not proven their relative effectiveness compared to traditional in-class teaching.

In the health sector, African mobile health (mHealth) projects under study benefitted from a high level of take-up and adherence among patients, health workers and staff. The authors identified the following recurring positive outcomes of these projects: better patient access to basic health services such as medical appointments, reduced delays in communication between patients and health staff, improved data collection and reporting, reduced patient travel costs, better health worker compliance to treatment guidelines, and improved patient sensitization and medication outcomes. Among other things, the authors point out that questions of health staff training in use of mobile technology, monitoring and evaluation of technologies, and setting adequate incentives are central for the success of mHealth project management. They also stress the importance of integrating such projects into the healthcare system, into the local context (for instance, by making the mHealth application available in local languages), and of promoting partnerships with public or private entities such as NGOs, universities, research institutes, and hospitals.

Lastly, various studies on the impact of using mobile money for private-to-private transfers and government-to-private transfers stress that such digital technology can be a very effective means of

improving household financial inclusion and resilience to shocks, and ultimately of moving people out of poverty. These benefits are stronger for women and female-headed households, which suggests that financial inclusion through mobile money might be particularly effective at fostering women's socioeconomic empowerment. One last lesson that can be drawn from these studies is that the size and coverage of the MM agent network, especially in rural areas where travel costs are highest, is a critical determinant of MM adoption, diffusion, and impacts.

1. Introduction

Accessible, affordable and qualitative public service[1] delivery is critical for the well-being of populations living in developing countries and for the functioning of their economy, but these services are often undermined by market imperfections and weak institutions (Aker, 2017).

In light of these challenges, the digitalization process observed in many low and middle-income countries, resulting from the sustained growth in the coverage of mobile networks and the concomitant reduction in information and communication technologies[2] (ICTs) usage gap opened up economic opportunities and helped leapfrog a number of development obstacles, , especially in remote rural areas (Aker and Mbiti, 2010; Aker 2011; Aker 2017). ICTs, more particularly broadband Internet and mobile technologies have the potential to become general-purpose technologies (Bresnahan & Trajtenberg, 1995) called upon to play an increasing role in the development process in Sub-Saharan Africa (SSA), including West Africa. By contributing to the emergence and dissemination of innovations in various sectors such as education, health, utilities, agricultural extension, financial services, and other sectors, the bourgeoning digitization of economies in SSA has raised the prospects of growth, employment and poverty reduction in the region (Aker & Mbiti, 2010; Andrianaivo & Kpodar, 2011; World Bank, 2016; Aker, 2017; Hjort & Poulsen, 2019).

However, throughout Sub-Saharan Africa as a whole and in West Africa in particular, the expected dividends of digital technologies have been slow to materialize and have fallen short of benefitting the whole population (World Bank, 2016). These low digital dividends are explained by a large multidimensional digital divide, induced by the poor spatial coverage of telecommunications and energy infrastructures, especially in rural areas, by low literacy and numeracy rates in many communities, and by the unaffordability of Internet-related services for the majority of the population. Yet, despite these obstacles to ICT penetration, numerous digital public service initiatives – including mobile money – have built on the large adoption of the mobile phone and have spread over the region. In 2017, amongst the approximately 400 digital initiatives deployed worldwide, more than half were located in SSA (GSMA, 2019a; Briter Bridges, 2019), covering a variety of sectors, especially in the areas of agriculture, education, and health sectors and in social protection (Aker, 2011, 2017; Aker & Blumenstock, 2014).

Empirical researches on the consequences of digitalization in these sectors suggest that digital interventions or innovations have generally yield positive economic and social outcomes. In sectors like agriculture, digital public service provision such as digital agricultural extension programs have seemed to improve the efficiency of agricultural markets. Results are more mixed, however, in the area of education, despite the relatively large number of initiatives in these sectors. In the health sector, the emergence and diffusion of innovations such as mobile health (mHealth) have contributed to foster health systems' functioning and inclusiveness, by promoting health behaviors and facilitating health worker's interventions. Overall, although many digital innovations have been successfully deployed in SSA, there are structural obstacles to scaling up, which as of yet have precluded digital technologies from playing their intended role of "engines of growth" (Bresnahan & Trajtenberg, 1995).

[1] According to Aker (2017, p.201): "Broadly is defined as the provision of services to promote economic, social and environmental sustainability".

[2] Information and communication technologies (ICTs) encompass the different types of platforms by which information flows and communications are made (mobile phones, smartphones, computers, tablets, radios, pagers/beepers, etc.), the different functions enabled by these platforms (communications, information dissemination, information collection, information processing), and the various types of content transmitted through them (calls, text messages, emails, websites, videos, radio broadcasts, radio messages, etc.).

The objective of this report is to promote a deeper understanding of the process of digitization of public service provision in SSA in general and West Africa in particular by highlighting the opportunities and challenges faced by digital initiatives multiplication across the region. The next section of this report provides a general background explaining the mechanisms by which public services delivery can be improved, painting a picture of the current state of digitization across SSA. This first step is necessary to understand where SSA is starting from in terms of digitization, and what is needed for digital technologies to spur the region to catch up in providing access to public services. In the third section, once the global picture of the ICT-public service nexus in Sub-Saharan Africa is given, the report goes into the details of selected digital initiatives by proposing a review of evidence-based analyses of African digital interventions that aims to unravel the reasons for their success or failure. The fourth section synthesizes the main report's findings and draws some policy implications.

2. Digitalization and public services provision in Sub-Saharan African economies: general background

Goldfarb and Tucker (2019) define digital technologies as "the representation of information in bits […] rather than atoms", which "reduces the cost of storage, computation and transmission of data" (p.3). This definition depicts digital technologies as a type of ICTs with a strong cost-reduction potential. This capacity to reduce various types of cost – information, travel, tracking, and replication costs – makes digital technologies "enabling technologies" (Bresnahan & Trajtenberg, 1995), offering solutions when public services provision is undermined by market failures (Aker, 2017).[3] This section maps out the expected benefits of improved public services delivery in West Africa and compares expected benefits to the reality of the digitization process in the region. The first subsection describes the mechanisms by which digital technologies can leverage public service provision, while the second section assesses the state of ICT coverage in Sub-Saharan and West Africa.

2.1. Digital technologies, cost reduction and market failures in public service provision

Following Aker (2017), and Goldfarb and Tucker (2019), it is possible to identify four interrelated areas of cost reduction induced by digital technologies adoption: information search costs, replication costs, transportation costs, and tracking and verification costs.

2.1.1. Digital technologies and information search costs reduction.

High information search costs translate into informational asymmetries between economic agents – individuals, households, the private sector, government, administrations – which explains why markets may fail in the delivery of public services in SSA (Finan et al, 2015; Aker, 2017). Imperfect information undermines the monitoring of public service provision, which may lead to situations of corruption, absenteeism, shirking, or clientelism. Imperfect information may also lead to allocative inefficiency and suboptimal taxation or pricing of public goods when public service providers have excessive market powers or are unable to observe preferences or willingness-to-pay of public services beneficiaries (Aker, 2017; Bjorkegren, 2019). Regarding beneficiaries, information asymmetries also translate into insufficient knowledge regarding location, quality, and conditions (eligibility) of public services delivery (World Bank, 2016).

[3] For the purposes of this report, digital technologies and ICTs are used interchangeably.

The digitization of information and communication has considerably reduced the monetary and opportunity costs of information searching, since digitized information is generally quickly made public, centralized and easily accessible. This reduction in information search costs associated with digital technologies adoption enlarges the scope, quality, and timeliness of information searching. Information digitization therefore has direct impacts on informational asymmetries between economic agents, reducing *price dispersion* and improving *matching* of buyers and sellers (Jensen, 2007; Aker, 2010; Aker & Fafchamps, 2014), increasing the *variety* of goods and services (Aker & Ksoll, 2015; Suri, 2017; Aron, 2018; Bjorkengren & Grissen, 2018), and reinforcing the *monitoring* of public administrations (Cilliers et al, 2018; Adida et al, 2018; McNabb et al, 2018). Information cost reduction is therefore one powerful channel through which digital technologies can improve public service provision.

2.1.2. Digital technologies and replication cost

Digital technologies create public goods (Goldfarb & Tucker, 2019). In fact, one important consequence of digitization for public services delivery is the zero-marginal cost associated with the production of digital goods, implying that such goods are non-rival[4]. This feature has important consequences for public services provision when the service to be delivered can be dematerialized, replicated at zero cost, and then disseminated to its intended beneficiaries. In the education sector, public posting of digitized pedagogical materials, together with the improved access of populations to low-cost digital platforms such as the XO tablet, has opened new perspectives for improving access to and quality of educational services (Menascé & Clément, 2017). The non-rivalry of digitized public information has also revolutionized agricultural extension programs by facilitating access to agricultural market information and the spread of agricultural technologies (Aker, 2011; Aker et al, 2016; Courtois & Subervie, 2014). The same process is observable in the health sector, as health workers can easily and remotely send health reminders and advice through communication technologies (Yé et al, 2018).

2.1.3. Digital technologies and distance-related costs

A corollary of the zero-replication cost of digital goods is the drastic reduction in transportation costs of digital content, such as electronic money or information, from one place to another.[5] In many low-income countries, communication through mobile phones has replaced expensive, time-consuming personal travel that was once necessary for many transactions, including patient follow-up in the health sector, extension agent field visits in the agricultural sector, borrower monitoring in the financial sector, etc. Combined with the information search costs as described in section 2.1.1, the reduction in information transportation costs was expected to diminish the role of physical distance in economic transactions (Cairncross, 2002), since distant parties involved in a transaction can have easy access to information on their counterpart and on the product/service exchanged through digital technologies. In support of this assertion, Lendle et al (2016) have shown that the effect of distance was 65% smaller for e-Bay purchases compared to international trade flows. In a study conducted in Niger, Aker (2010) finds that the reduction of commodity price dispersion resulting from access to mobile phone technology is stronger when agricultural markets are distant, or when the road infrastructure quality is poorer. In the same context, Tack and Aker (2014) have stressed that mobile phone adoption has extended the geographical perimeter of farmers' market information search. The reduced virtual distance between economic agents equipped with mobile technologies enabling electronic payments also increased interpersonal transfers and risk-sharing through mobile money in Kenya (Jack et al, 2013; Jack & Suri, 2014; Riley, 2018). In the education sector, Adida et al (2018) study the benefits of a digital platform

[4] "A key distinction between goods made of atoms and goods made of bits is that bits are non-rival, meaning that they can be consumed by one person without reducing the amount or quality available to others" (Goldfarb & Tucker, 2019).

[5] Under the condition of absence of network congestion in Internet traffic (Goldfarb & Tucker, 2019)

facilitating electronic school fee payments by their remote relatives. In the health sector, various mobile applications enable remote follow-up of patients (McNabb et al, 2015).

2.1.4. Digital technologies and tracking, targeting, and verification costs

In relation to previous costs reduction, the digitization of information has enabled the centralization and storage of information, thereby reducing the costs of collecting and processing information on market conditions, public service users or administrations (Aker, 2017). Digital data collection can take several forms, from phone calls or SMS-based surveys to mobile-money transactions data or "digital footprints left behind in the transaction logs of mobile phones" (Blumenstock, 2016). Putting aside the important privacy issues stemming from the exploitation of personal information made available by DT usage (Blumenstock, 2016), digitization of information can be beneficial to public goods provision, when providers can obtain better information on citizen's preferences and can better target public good recipients (McNabb et al, 2015), or when citizens can monitor government administrations and make public goods providers more accountable (Aker & Blumentsock, 2014; Aker, 2017). Digital technologies could therefore be instrumental to state interventions by driving the modernization of public administrations in low-income countries, as highlighted by Liu and Yuan (2015). This centralization of information through digital technologies has also reduced the need for costly verification and facilitated trust in economic exchanges by improving the reliability of information collected and processed by economic agents (Zanello et al, 2014).[6]

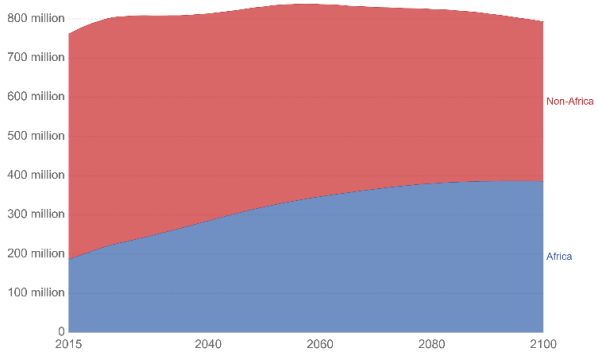
Overall, digital technologies have the potential to leapfrog infrastructures, processes, administrations, and institutions that have been put in place in industrialized countries to reduce market failures, but which are missing or failing in low-income countries. This potential however greatly depends on ICT adoption and diffusion in the population. The next subsection looks more closely at the state of digitization in SSA and West Africa.

2.2. Where does the digitization of Sub-Saharan and West Africa stand?

In Africa, expectations of the digital economy to take-off, to create jobs, and to offer satisfying living conditions to populations are particularly important. According to the United Nations, demographic forecasts for the entire SSA region project an increase in the population size from 1.3 billion inhabitants in 2020 to 2.5 billion in 2050, meaning that the African population will represent around a quarter of the world's total population within 30 years. West Africa follows the same trend, as its population is projected to grow from 402 million in 2020 to 796.5 million in 2050, representing around one-third of the project African population in 2050. UN projections of the world population of 6-11 year-old children suggest that almost half of the world's youth population will be Africa in 2100 (Figure 1). It is therefore in this region that economic and social transformations induced by digital technology dissemination could be the deepest.

[6] Keeping in mind that digital technologies also facilitate the circulation of false information such as rumors and bot-induced online ratings.

FIGURE 1. YOUTH POPULATION (6 TO 11 YEARS-OLD) PROJECTION, AFRICA VS REST OF THE WORLD

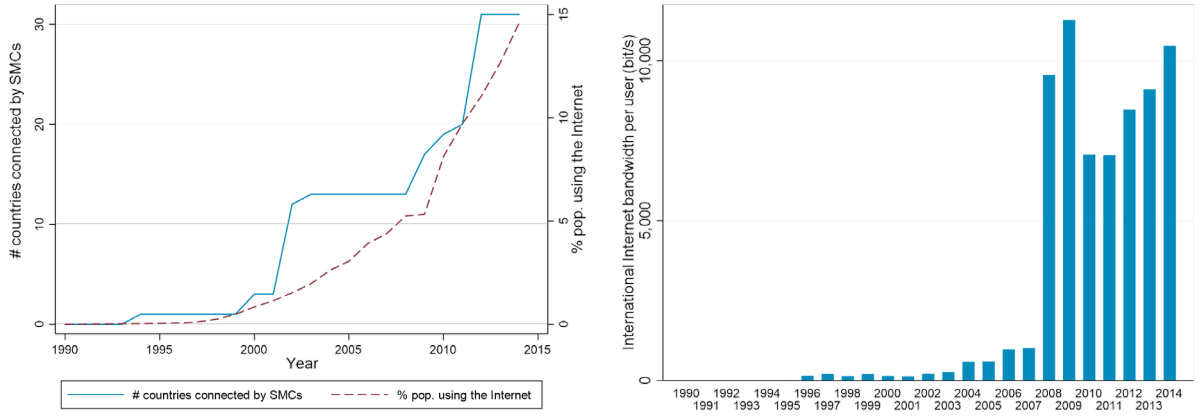


Source: UN Population Division (2017 revision), based on the median fertility scenario. https://ourworldindata.org/.

2.2.1. The Internet divide in SSA

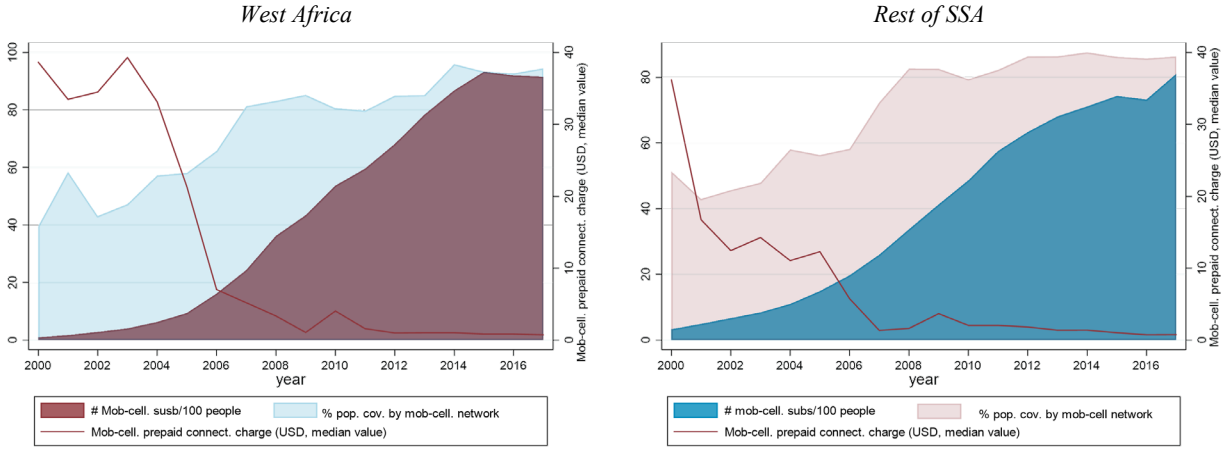
In a recent paper, Cariolle (2020) stresses that the laying of telecommunications submarine cables in 2009-2010 along African coasts has brought broadband Internet and has accelerated the uptake of Internet in populations throughout the region, yielding a 3-5 average percentage point increase in Internet penetration rates in SSA (Figure 2). This positive relationship between broadband arrival and Internet adoption is independent of the trend of continuous diffusion of mobile phones throughout the region since 2000 (Figure 3). As shown in Figure 3, the diffusion of mobile devices throughout the population has been exponential since 2000, that is, prior to the quantum leap in international Internet bandwidth capacity; there has also been an exponential decrease in the median charge for mobile prepaid connections and the increase in the share of the population covered by mobile networks. As pointed out by Aker and Mbiti (2010), the mobile phone has leapfrogged missing landline infrastructures, especially in rural areas, so that mobile phone devices represent the principal digital service delivery platform. As shown in Figure 3, mobile penetration and coverage in West Africa followed a slightly higher pace of progression than the rest of SSA, despite a later decline in mobile phone prepaid tariffs. Overall, in 2016, more than 80% of the population across the region was covered by a mobile network, almost all Africans owned a mobile phone device, and the median mobile prepaid connection charge was below $1.00 US.

FIGURE 2. INTERNATIONAL CONNECTIVITY AND INTERNET PENETRATION IN SSA.



Sources: Cariolle (2020), from ITU and Telegeography datasets. SMCs: telecommunication submarine cables.

FIGURE 3. MOBILE PHONE PENETRATION IN WEST AFRICA AND SSA

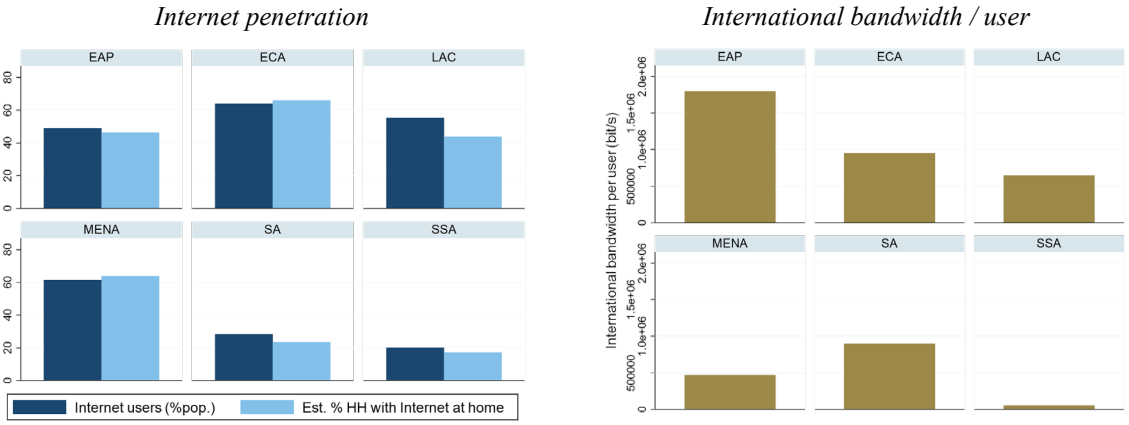


Source: Authors, from ITU dataset. West Africa encompasses ECOWAS countries.

Digital initiatives that have benefitted from a large diffusion in the population are generally based on simple communications technologies (phone calls, text messages) or on mobile money, and do not rely on Internet access nor require owning a sophisticated communications device (Aker & Blumenstock, 2014). The simplicity in the access and use of digital technologies is indeed probably a precondition for unleashing its leapfrogging potential. In addition, the rise in African digital innovations has to be examined in light of another reality: in 2016, only 20% of the African population (including West Africans) had used the Internet and less than 20% of households had an Internet connection at home (Figure 4). To illustrate this concern, Mothobi and Grzybowski (2017) find that in 11 SSA countries, people remote from physical infrastructures are more inclined to use their mobile phone to make financial transactions (mobile money) than people with access to such infrastructures.

The potential for rollout of the newest generation of information technologies in SSA – i.e. blockchain technologies, artificial intelligence, cloud computing, etc. – therefore faces a serious barrier in terms of the Internet divide in the population. Beyond the low Internet penetration rates that are characteristic of the region, this Internet divide is also striking in terms of broadband capacity and affordability. Despite the rapid progression of the international bandwidth per user induced by the recent laying of submarine cables, SSA lags very far behind other developing areas (Figure 4), while the speed and cost of access to broadband Internet remains highly prohibitive in a number of African countries compared to other regions (Figure 5).

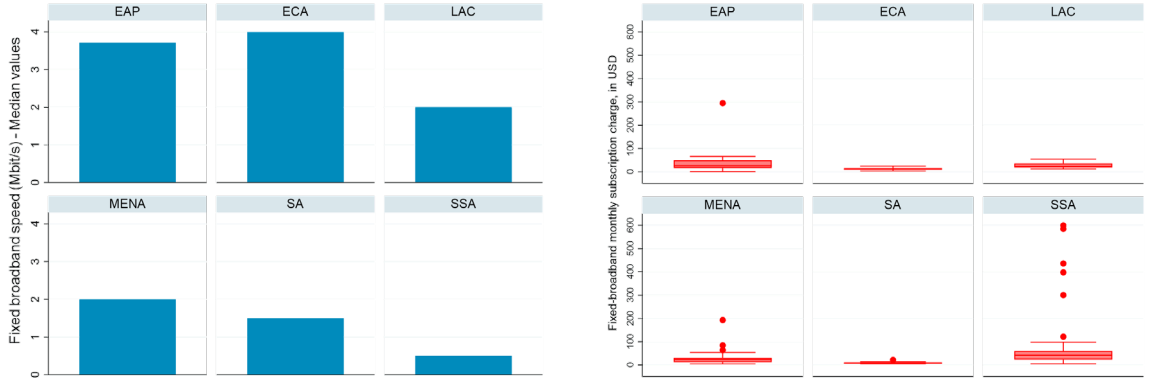
FIGURE 4. INTERNET PENETRATION RATES AND BANDWIDTH PER USER IN 2016 ACROSS DEVELOPING REGIONS.



Source: Authors, from ITU database. EAP: East Asia and Pacific region. ECA: Eastern and Central Europe. LAC: Latin America and the Caribbean. MENA: Middle East and North Africa. SA: South Asia. SSA: Sub-Saharan Africa.

FIGURE 5. SPEED AND AFFORDABILITY OF BROADBAND INTERNET, SSA VERSUS OTHER DEVELOPING REGIONS.

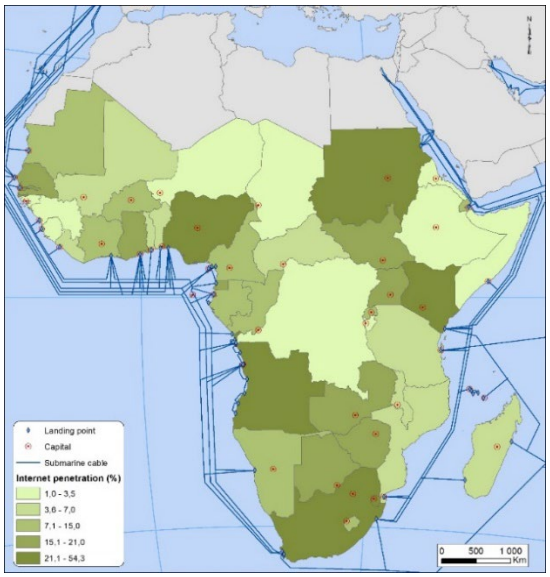
Fixed broadband speed, 2016 *Fixed broadband monthly subs. charge (USD), 2014*



Source: Authors, from ITU database. EAP: East Asia and Pacific region. ECA: Eastern and Central Europe. LAC: Latin America and Caribbean. MENA: Middle East and North Africa. SA: South Asia. SSA: Sub-Saharan Africa.

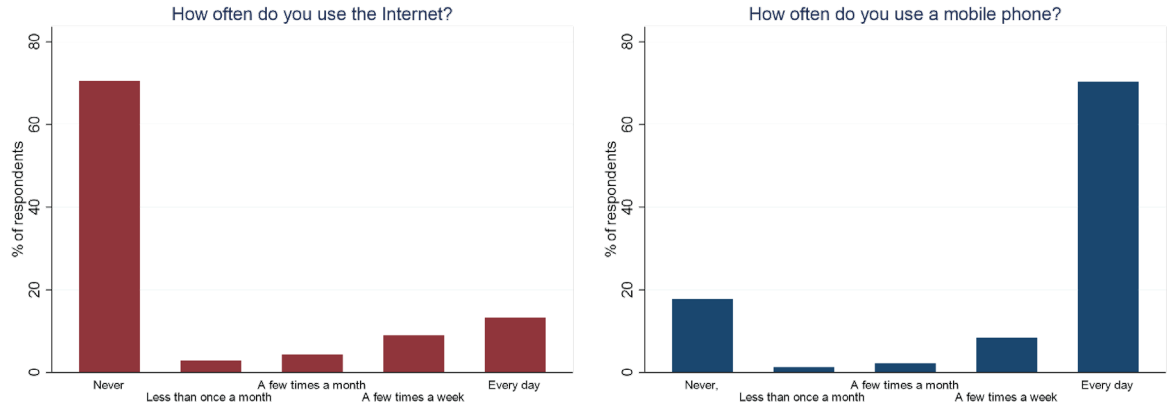
Within SSA, Internet penetration rates did not exceed 54.3% of the population in 2015 (see Map 1). South Africa, Kenya, Angola, Sudan, Nigeria and Ghana were in the highest penetration rate quintile, with Internet penetration rates lying between 21% and 54% percent of the population. However, Internet penetration in Francophone landlocked countries did not exceed 7%; and among West African countries, Niger, Sierra-Leone, Guinea, and Guinea-Bissau had penetration rates lower than 3.6 percent of the population. Looking at Internet and mobile phone adoption behaviors within the African population, Afrobarometer surveys conducted over a sample of some 50,000 African citizens in 2014 and 2015 in 32 SSA countries stress that the pattern of frequency in Internet use is the exact opposite of mobile phone use (Figure 6). In fact, while 70% of respondents reported never having used the Internet, only 13% of the same respondents reported never having used a mobile phone. By contrast, only 18% of respondents reported using the Internet on a daily basis, while 70% of them declared using a mobile phone every day. These patterns are similar when surveys are confined to West African countries (Figure 7). In the next subsection, we show that these patterns differ according to gender, geography, revenue, and education.

MAP 1. INTERNET PENETRATION RATES IN SUB-SAHARAN AFRICA, 2015.



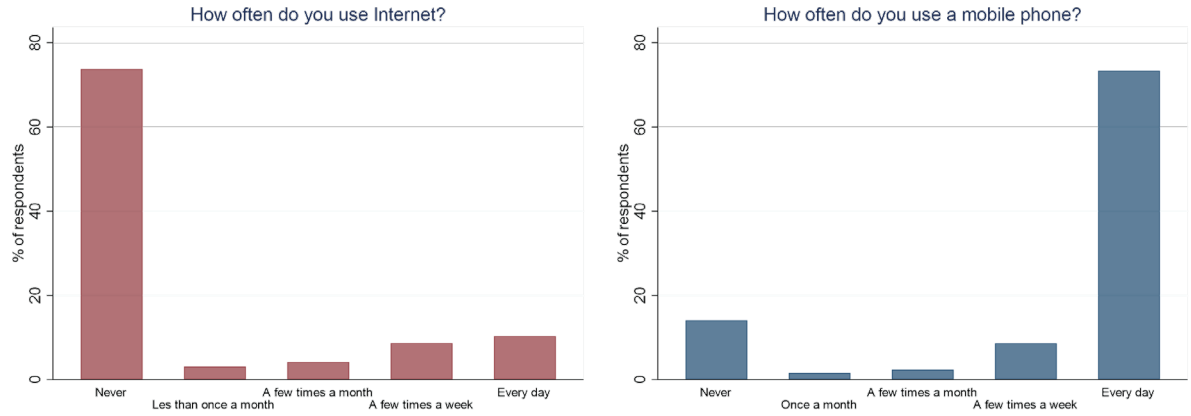
Sources: Authors. Data from ITU database. Telegeography.

FIGURE 6. FREQUENCY OF INTERNET AND MOBILE PHONE USAGE IN SSA.



Source: Afrobarometer, 6th round. Sample: 48,283/48.966 respondents (left/right-side graphs). Surveys conducted in 32 SSA countries between 2014 and 2015. Sample weights are applied.

FIGURE 7. FREQUENCY OF INTERNET AND MOBILE PHONE USAGE IN WEST AFRICA.



Source: Afrobarometer, 6th round. Sample: 17,750/17,912 respondents (left/right-side graphs).West African countries: Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Ghana, Guinea, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Togo. Surveys conducted between 2014 and 2015. Sample weights are applied.

2.2.2. A multi-dimensional digital divide

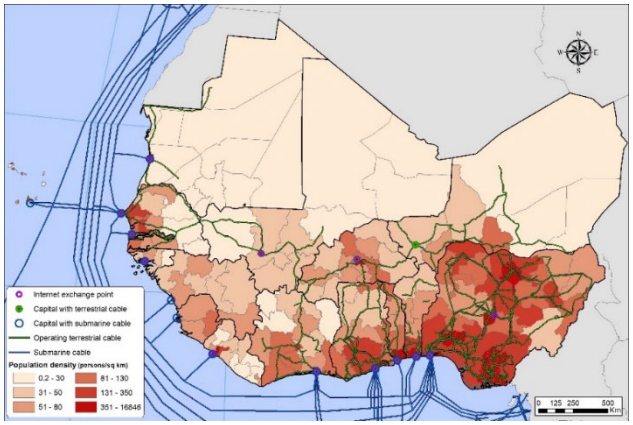
In SSA, important differences in access to digital technologies can be observed among and across populations. This heterogeneity is explained by demand-side factors, including literacy and numeracy skills necessary to use digital technologies, but also supply-side factors, such as mobile or fiber infrastructure coverage. As a result, the digital divide is multidimensional, differing according to economic status (rich versus poor), geography (urban versus rural areas), gender (male versus female), and education level (educated versus uneducated). Taking into account the different dimensions that condition the adoption of mobile telephone and/or Internet services is necessary to realize the expected dividends of digitization. We emphasize below four key dimensions of the digital divide.

The spatial digital divide

According to ITU (2019), in 2017, only 65% percent of the population had access to the 3G network. Coverage was even lower in West African countries, reaching only 56% of the population (against 68% in the rest of SSA), illustrated by the unequal distribution of the fiber backbone infrastructure, serving

only major demographic centers in some countries such as Nigeria, Côte d'Ivoire, and Burkina Faso, or totally absent in others like Guinea and Sierra-Leone (Map 2).

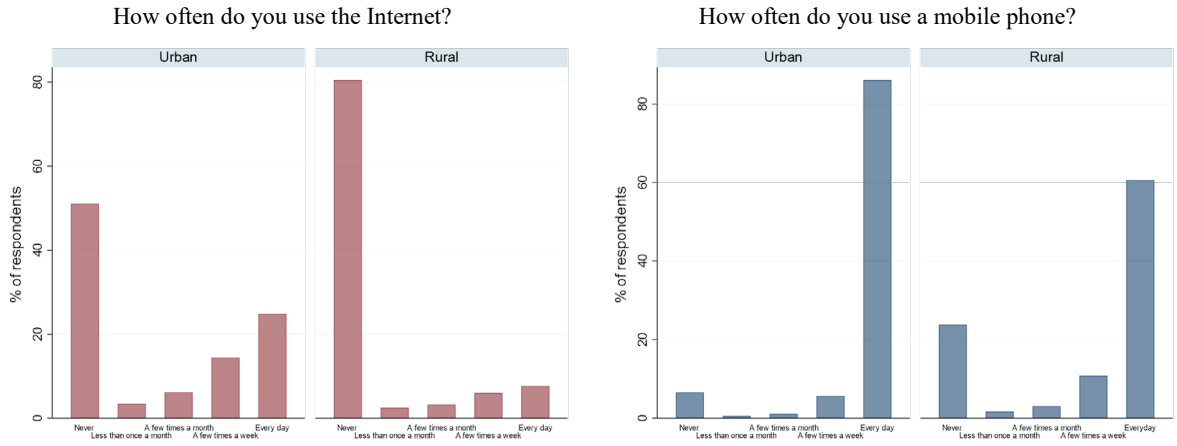
MAP 2. BACKBONE INFRASTRUCTURE DEPLOYMENT AND POPULATION DENSITIES IN WEST AFRICA, IN 2015.



Source: Authors. Data from Telegeography, Peering DB, Packet Clearing House databases.

Despite the rapid catch-up of mobile network extension in recent years (Figure 3), the geographical coverage of fiber and mobile Internet infrastructure in SSA remains uneven between rural and urban areas. This spatial digital divide is striking when looking at Internet adoption, as 80% of Afrobarometer respondents located in rural areas declared never having used the Internet, against half of the population surveyed in urban areas (Figure 8). However, this divide is also evident if we look at the adoption of basic communication technologies such as the mobile phone. In fact, only 60% of rural respondents declared using a mobile phone on a daily basis, against more than 80% of urban respondents.

FIGURE 8. THE SPATIAL DIGITAL DIVIDE, URBAN VERSUS RURAL POPULATIONS.

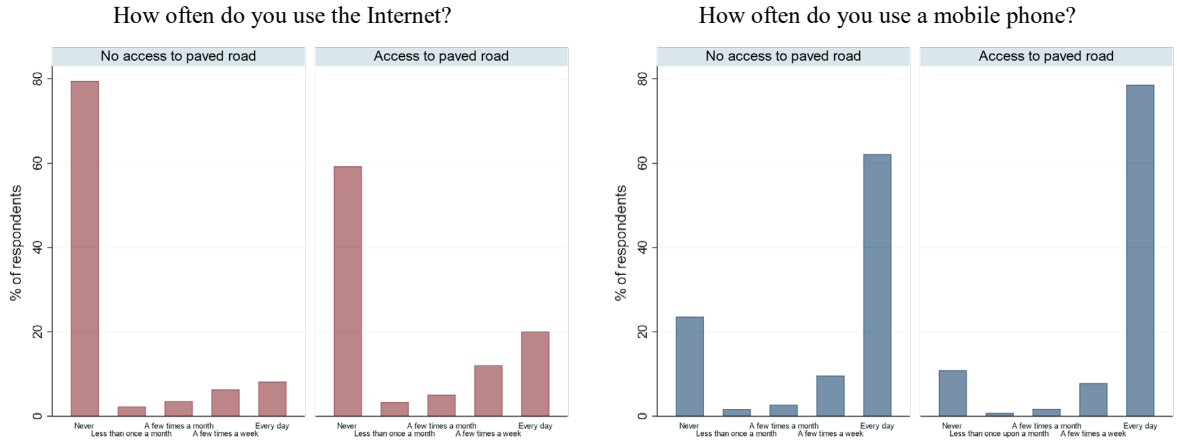


Source: Afrobarometer, 6th round. Sample: 17,750/17,912 respondents (left/right-side graphs). Sample weights are applied.

The geography of the digital divide is also strongly related to other critical infrastructure, such as road or energy infrastructure, so that digital and physical isolation of populations remote from urban centers have a compounding effect. Figure 9 below illustrates the gap in Internet and mobile phone use between populations with and without access to paved roads. Again, the divide is striking, as 80% of Afrobarometer respondents without access to paved roads declared having never used the Internet, and only 60% of these same respondents declared using a mobile phone every day. By contrast, only 60% of respondents with access to paved roads declared having never used the Internet and 80% of them declared using a mobile phone every day.

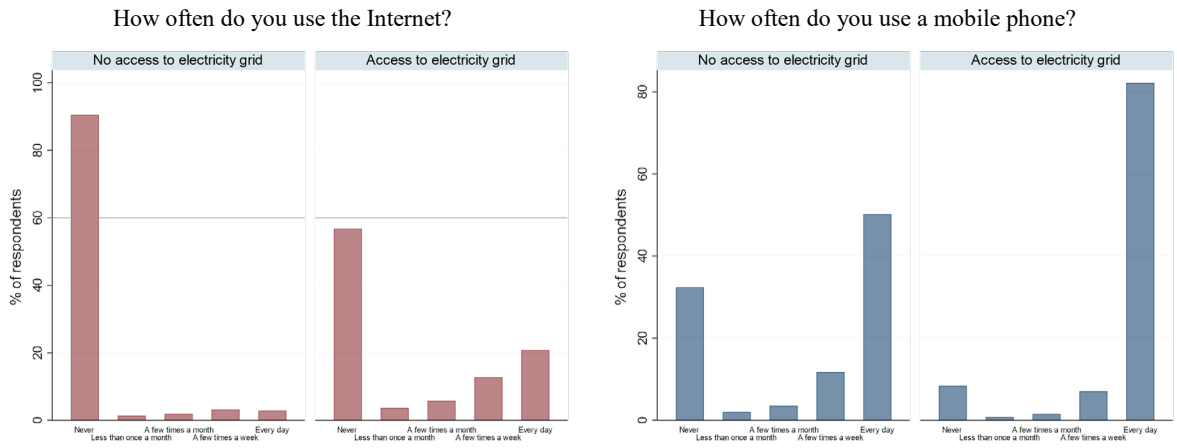
The contrast becomes even clearer when considering populations' access to the electricity infrastructure, as in Figure 10. This figure shows that some 90% of respondents without access to the electrical grid have never used the Internet, against less than 60% of respondents with electricity access. Moreover, around 30% of respondents without electricity access declared having never used a mobile phone, which is significantly higher than the less than 10% of populations with electricity access.

FIGURE 9. THE SPATIAL DIGITAL DIVIDE AND GEOGRAPHICAL ISOLATION.



Source: Afrobarometer, 6th round. Sample: 17,750/17,912 respondents (left/right-side graphs). Sample weights are applied.

FIGURE 10. THE SPATIAL DIGITAL DIVIDE AND ENERGY DEPRIVATION.

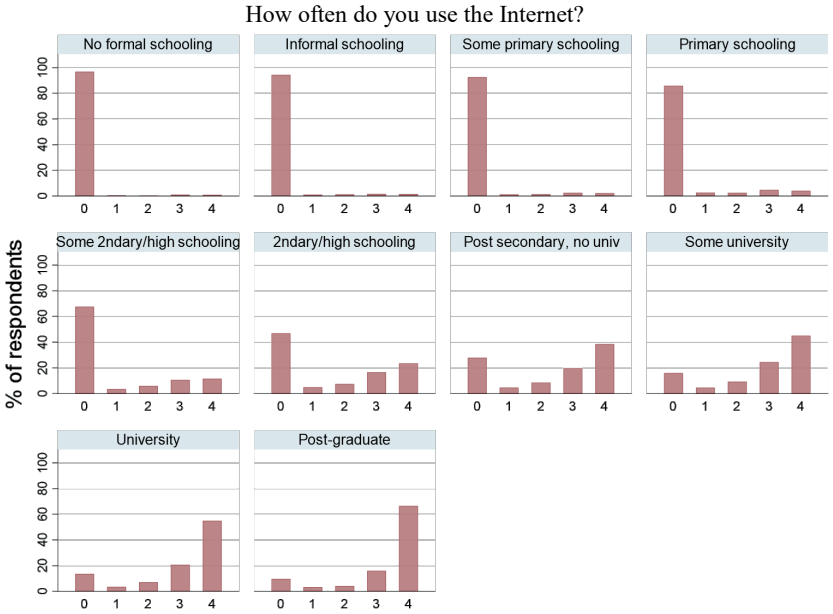


Source: Afrobarometer, 6th round. Sample: 17,734/17,896 respondents (left/right-side graphs). Sample weights are applied.

The educational digital divide.

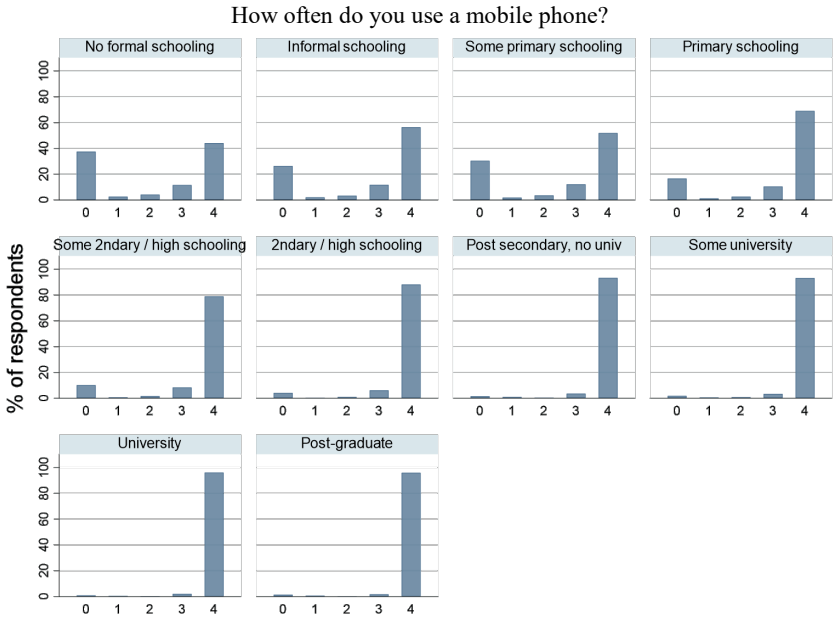
The unequal coverage of Internet infrastructure often overlaps with the uneven spatial distribution of road and energy infrastructures, but also of educational infrastructure. Consequently, in addition to physical isolation and energy deprivation driving poor access to ICTs among rural populations, they also often lack the minimum literacy and numeracy skills necessary to adopt them. In fact, the digital divide is also educational, as clearly evidenced by Figures 11 and 12. In Figure 11, the Internet divide is striking among low-educated populations, as more than 80% of respondents with primary school level or less have never used the Internet. The share of people who have never used the Internet sharply declines at intermediate education levels, but a truly high occurrence of Internet use is only observable at the highest level of education (university or postgraduate education). In Figure 12, the mobile adoption gap is observable through the low share of less-educated people (primary schooling or less) declaring using a mobile phone on a daily basis. By contrast, the share of respondents declaring using a mobile phone every day reaches at least 80% in populations with secondary schooling or higher.

FIGURE 11. EDUCATION LEVEL AND THE INTERNET DIVIDE



Source: Afrobarometer, 6th round. Sample: 17,701 respondents. 0=Never, 1=Less than once a month, 2=A few times a month, 3=A few times a week, 4=Every day. The question on education level was: "What is your highest level of education?".

FIGURE 12. EDUCATION LEVEL AND THE MOBILE DIVIDE



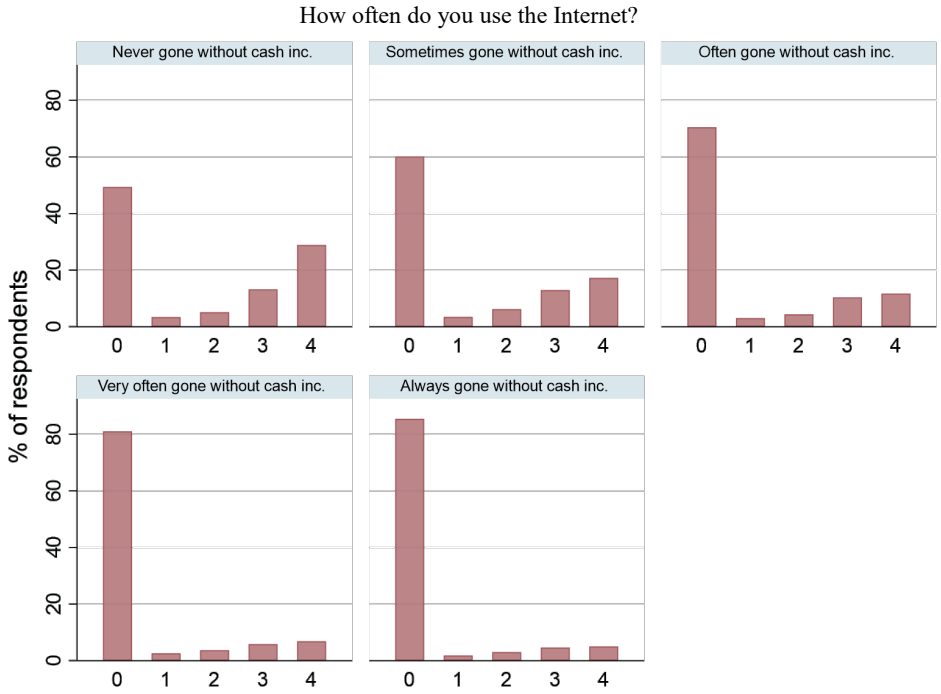
Source: Afrobarometer, 6th round. Sample: 17,861 respondents. 0=Never, 1=Less than once a month, 2=A few times a month, 3=A few times a week, 4=Every day. The question on education level was: "What is your highest level of education?".

The digital divide and the income gap

The multidimensional nature of the digital divide, illustrated in earlier subsections, combined with the high telecommunication tariffs charged by African operators and Internet Service Providers (Figure 5), makes income level a key determinant of ICT access. While information on income earned by individuals is not provided by Afrobarometer surveys, the survey does provide information on the frequency of cash income earnings. Figures 14 and 15 compare the frequency of Internet or mobile phone use with the frequency of cash income earning within households. Figure 13 stresses that the share of respondents declaring having never used the Internet strongly increases when the frequency of

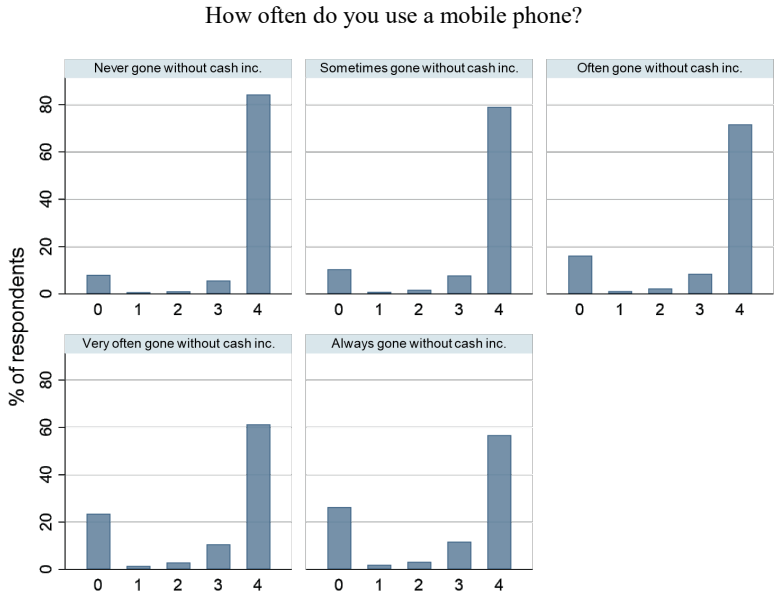
earning cash lowers. In Figure 14, we observe that the share of respondents using a mobile phone on a daily basis strictly decreases when cash flows become scarcer. Therefore, the digital divide is also reflected by the income gap.

FIGURE 13. CASH INCOME AND THE INTERNET DIVIDE



Source: Afrobarometer, 6th round. Sample: 17,694/17,855 respondents (left/right-side graphs). 0=Never, 1=Less than once a month, 2=A few times a month, 3=A few times a week, 4=Every day. The question on cash income flow was: "Over the past year, how often have you or your family gone without a cash income?"

FIGURE 14. CASH INCOME AND THE MOBILE DIVIDE

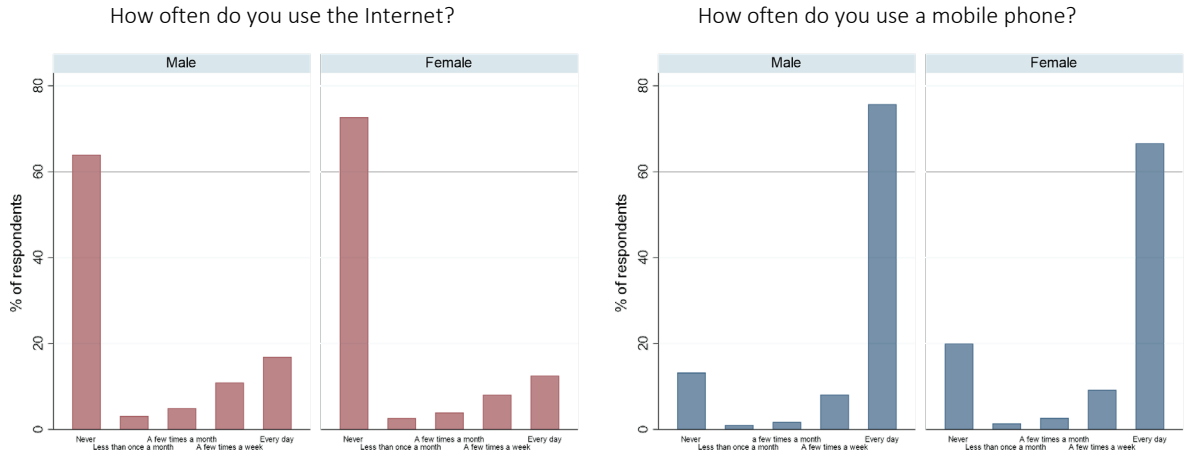


Source: Afrobarometer, 6th round. Sample: 17,694/17,855 respondents (left/right-side graphs). 0=Never, 1=Less than once a month, 2=A few times a month, 3=A few times a week, 4=Every day. The question on cash income flow was: "Over the past year, how often, have you or your family gone without a cash income?"

The gender digital divide

One last logical dimension stemming from all other dimensions of the digital divide is the gender digital gap. Discrimination in access to education, health, within-household resources, or financial services often experienced by women is indeed also a significant factor in terms of access to ICTs. In fact, Figure 15 below shows that the share of women who declared never having used the Internet is high at 80% of respondents when compared to the percentage of male respondents at 60%. Regarding mobile phone usage, the share of women declaring having never used a mobile phone is 20%, compared to 13% of male respondents, while the share of women declaring using a mobile phone every day is 67%, compared to 76% of male respondents. Therefore, the digital gender gap is an additional dimension of gender inequalities existing in the region. However, Suri and Jack (2016) support that ICT interventions, and in particular mobile money interventions, targeted to women not only increase their welfare (in terms of occupational choice) but also have a greater poverty-reducing effect.

FIGURE 15. DIGITAL DIVIDE AND THE GENDER GAP



Source: Afrobarometer, 6th round. Sample: 17,694/17,855 respondents (left/right-hand side graphs).

2.3. ICT diffusion in selected West African countries

This subsection provides background details on the specific contexts of various evidenced-based intervention analyses that will be presented in Section 3. First, we describe the case of Niger, a low-income, rural, landlocked, francophone West-African country, has received various mobile-based interventions in multiple areas of public service provision, including agricultural extension, education, and anti-poverty programs. Second, we focus on Ghana, a fast-growing coastal anglophone country with one of the highest GDPs per capita in West Africa, where digital technologies have multiplied in recent years (Figure 4) and which has also received attention from researchers.

2.3.1. Access to ICTs in a Sahelian landlocked country: insights from Niger

According to the ITU (2019), 92% of the Nigerien population had access to the mobile network in 2017, but only 24% was covered by the 3G network and was therefore able to use the Internet through their mobile device. As shown in Table 1, using the Internet in Niger is very uncommon, especially in rural areas where 98% of respondents declare having never connected to the Internet. Internet adoption in urban centers does not seem to be easy either, as more than 80% of urban respondents declare using the Internet at most a few times per month (77% of them have never used it). Interventions aimed at improving access to public services through Internet technologies are therefore likely to face low take-up and as of yet have no grounds for scaling-up. Regarding mobile money adoption, only 9% of respondents of the Findex survey in Niger declared having a mobile money account in 2017, with this

figure probably much lower in rural areas, which is very far from the 77% mobile money account ownership among the Kenyan population (Demirgüç-Kunt et al, 2017). Again, despite evidence highlighting the benefits of public transfers using mobile money technology for rural populations in Niger presented in Section 3 (Aker et al, 2016b), this low penetration is a serious impediment to the scaling of such interventions.

TABLE 1. THE INTERNET DIVIDE IN NIGER

	How often do you use the Internet?		
	% of total	**% of urban**	**% of rural**
Never	94.27	77.02	97.61
Less than once a month	0.58	1.35	0.43
A few times a month	1.12	3.60	0.64
A few times a week	1.75	7.77	0.58
Every day	2.28	10.25	0.74

Data: Afrobarometer, 6th round. Survey conducted in 2014-2015. Sample: 1,192 respondents. Sample weights applied.

However, mobile phone-based public service interventions are much more likely to succeed with higher rates of mobile phone adoption among urban as well as rural populations (Table 2). Mobile phone services started to become operational only in some parts of Niger as of October 2001. Mobile coverage has since been deployed gradually, in priority in urban centers and locations close to international borders, and then extended to rural areas (Aker, 2010; Tack & Aker, 2014). Still, some populated areas in Niger (in the North of Niamey and Zinder) do not benefit from even 2G coverage, with almost no 3G coverage (see the Map 3 below). As a result, contrary to Internet use, 55% of respondents declared using a mobile phone every day (50% of rural respondents) in 2014-2015, and 60% of them owned a mobile phone (55% in rural areas) (Afrobarometer, 2016).

TABLE 2. THE MOBILE DIVIDE IN NIGER

	How often do you use a mobile phone?		
	% of total	**% of urban**	**% of rural**
Never	26.98	3.45	31.52
Less than once a month	4.63	2.13	5.12
A few times a month	3.38	1.23	3.80
A few times a week	9.88	9.21	10.01
Every day	55.13	83.98	49.56

Data: Afrobarometer, 6th round. Survey conducted in 2014-2015. Sample: 1,200 respondents. Sample weights applied.

Moreover, the potential of communications technologies such as mobile phones to move many Nigeriens out of poverty is probably very strong, given the various structural handicaps faced by Nigeriens that could be overcome through digital public services delivery (Aker, 2017). In fact, 44.5% of the population in Niger lives with less than less than $1.90 a day (World Bank, 2020). A large bulk of the poor is located in rural areas (Table 3), works in the agriculture sector, does not have access to effective and affordable communications technologies, but incurs large travel and opportunity costs related to the poor state of transportation infrastructure coverage.[7]

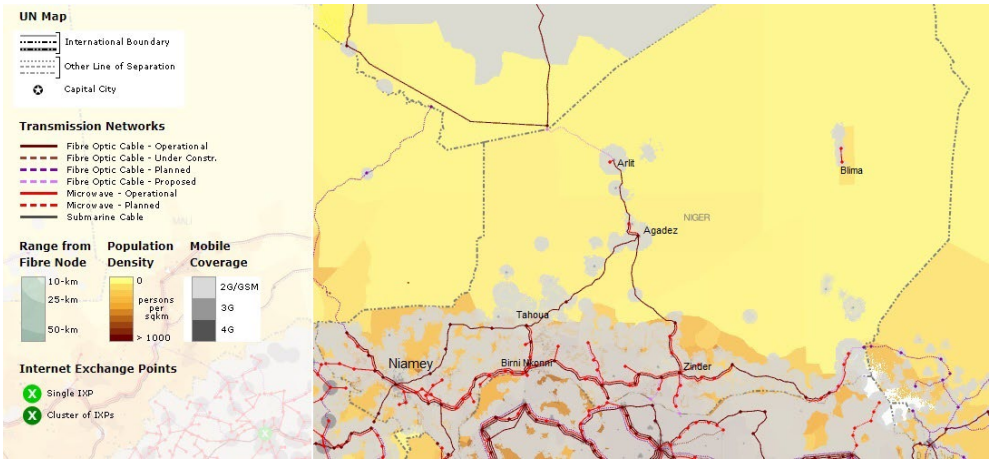
[7] In 2014, the road density was very low, equal to 0.69 km of roads per 1,000 km^2, and in 2016, only 20.4% of the road network was paved. Data drawn from the Sustainable Competitiveness Observatory (FERDI): https://competitivite.ferdi.fr/en

TABLE 3. THE SPATIAL INCOME GAP IN NIGER

Do you have a job that pays a cash income?			
	% of total	**% of urban**	**% of rural**
No, not looking for	59.67	51.04	61.31
No, looking for	23.33	15.63	24.80
Yes, part time	8.42	11.46	7.84
Yes full time	8.58	21.88	6.05

Data: Afrobarometer, 6th round. Survey conducted in 2014-2015. Sample: 1,200 respondents. Sample weights applied.

MAP 3. MOBILE AND INTERNET INFRASTRUCTURE ROLLOUT IN NIGER, 2019.



Source: ITU Interactive map, https://www.itu.int/itu-d/tnd-map-public/.

2.3.2. Access to ICTs in an industrializing West African coastal country: insights from Ghana

Unlike Niger or other landlocked West-African countries, Ghana is a coastal country, where 56% of the population lives in urban areas (World Bank, 2020), benefitting from dynamic agricultural and industrial sectors and from stable agricultural and GDP growth during the last two decades. The share of the GDP contributed by the Ghanaian agricultural sector has been declining over the years, representing only 19% of the GDP in 2018, but this sector still represents approximately 35% of total employment. Ghana faces a much less severe poverty rate than Niger, as 14% of the population lives on less than $1.90 a day. However, the rural population, mostly employed in the agricultural sector, is more exposed to poverty than its urban counterpart: in 2014-2015, 62% of Afrobarometer's respondents in rural Ghana declared not having a regular source of cash income against 46% in urban areas (Table 4).

TABLE 4. THE SPATIAL INCOME GAP IN GHANA

Do you have a job that pays a cash income?			
	% of total	**% of urban**	**% of rural**
No, not looking for	42.19	33.94	49.09
No, looking for	12.21	11.75	12.60
Yes, part time	23.09	25.55	21.03
Yes full time	15.41	18.33	12.97

Data: Afrobarometer, 6th round. Survey conducted in 2014-2015. Sample: 1,200 respondents. Sample weights applied.

According to the ITU (2019), 98% of the Ghanaian population had access to a mobile network in 2017, and 80% was covered by the 3G network, with the great majority of urban areas covered (Map 4), so that contrary to Niger, a large share of the population is able to access the Internet through their mobile

device. As shown in Table 5, using the Internet in Ghana is more common than in Niger, as almost 18% of Afrobarometer respondents and a quarter of those located in urban centers declare using it few times a week or every day. Still, a large part of the population has never used it, especially in rural areas where 88% of respondents declare having never used the Internet, compared to 67% in urban areas. Unsurprisingly, mobile money adoption is much larger in Ghana, as 43% of Findex survey respondents declared owning a mobile money account in 2017, which is still much lower than in Kenya but similar to Uganda (44%) and Tanzania (53%) (Demirgüç-Kunt et al, 2017). Despite an urban environment favorable to digital technologies take-up, rural populations remain excluded from this dynamic and face the same constraints as their Nigerien counterparts. In fact, evidence from Ghana presented in Section 3 (Courtois & Subervie, 2014; Zanello et al, 2014) stresses that rural farmers face the same market failures and derive the same benefits from using basic ICTs as do rural Nigerien rural.

TABLE 5. THE INTERNET DIVIDE IN GHANA

	How often do you use the Internet?		
	% of total	**% of urban**	**% of rural**
Never	76.40	66.96	87.66
Less than once a month	1.99	2.49	1.40
A few times a month	3.87	5.25	2.24
A few times a week	5.89	7.86	3.55
Every day	11.84	17.45	5.15

Data: Afrobarometer, 6th round. Survey conducted in 2014-2015. Sample: 2,351 respondents. Sample weights applied.

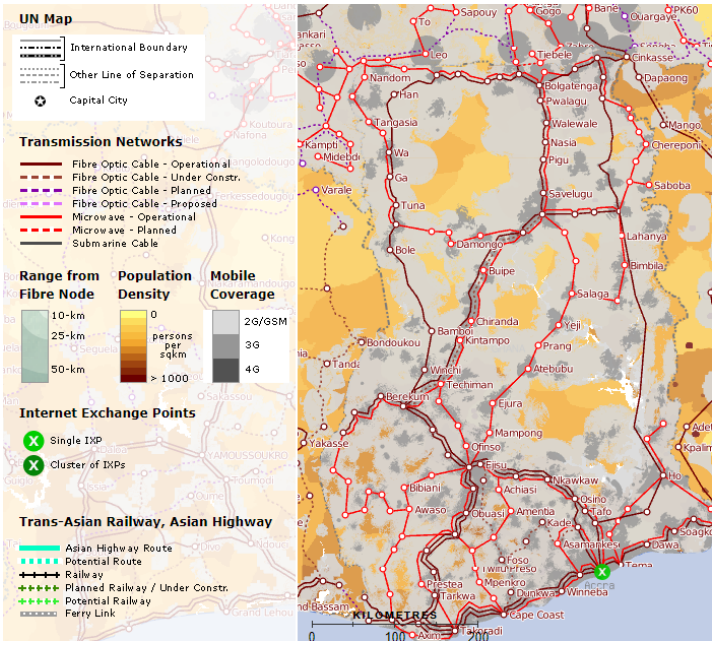
The potential for scaling ICT-based interventions aimed at improving public service provision in rural areas could therefore be large if the intervention builds on simple mobile phone technologies. Map 4 below shows that the telecommunications infrastructure network in Ghana is denser and has a wider coverage and a greater capacity to carry telecommunications than that of Niger. Moreover, Table 6 shows that Ghana displays a much higher proportion of people using mobile phones on a daily basis than does Niger, whether they live in urban (89%) or in rural (63%) areas. The proportion of mobile phone ownership is also large, as 82% of respondents declared owning a mobile phone (91% in urban centers against 71% in rural areas). But still, almost one quarter of rural respondents declared having never used a mobile phone and 28% of the same respondents do not own a mobile phone (Afrobarometer, 2016).

TABLE 6. THE MOBILE DIVIDE IN GHANA

	How often do you use a mobile phone?		
	% of total	**% of urban**	**% of rural**
Never	14.01	6.02	23.60
Less than once a month	1.10	0.89	1.34
A few times a month	1.91	0.89	3.13
A few times a week	5.75	3.23	8.77
Every day	77.23	88.97	63.16

Data: Afrobarometer, 6th round. Survey conducted in 2014-2015. Sample: 2,351 respondents. Sample weights applied.

MAP 4. MOBILE AND INTERNET INFRASTRUCTURE ROLLOUT IN GHANA, 2019.



Source: ITU Interactive map, https://www.itu.int/itu-d/tnd-map-public/.

2.4. Main lessons

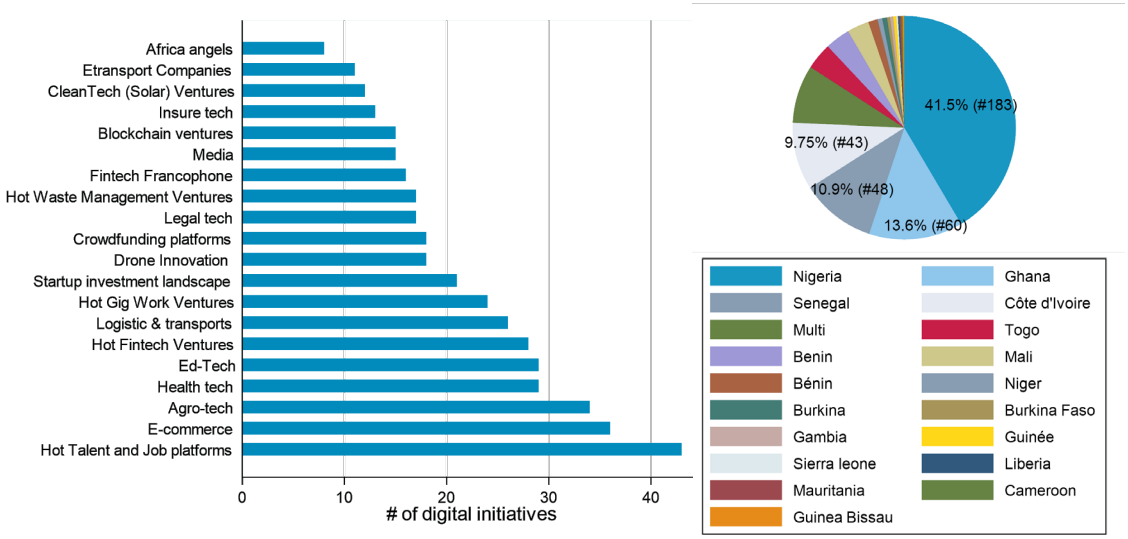
To sum this subsection up, populations excluded from public service provision are usually the same as those which are deprived from access to ICTs, so that ICT-based public service provision interventions that do not take into account the various dimensions of the digital divide as previously emphasized may fall short of achieving their intended purpose. In other words, such interventions, in order to maximize their development impact, should be designed to target rural populations remote from broadband infrastructures, characterized by low average literacy and numeracy rates and earning small income, and to address gender inequality. Moreover, despite the rapid uptake of mobile phones and multiplication of digital innovations in SSA, Internet penetration is still low compared to other developing areas. An environment more conducive to the adoption of internet-related technologies could certainly improve the digital dividends for public services delivery, employment, economic diversification, and private sector development in SSA economies (Ndulu, 2006; Schumann & Kende, 2013). However, interventions promoting digital public service provision through simple mobile phone use should benefit from a greater level of adoption among the population, especially in rural areas. As a result, most evidence-based studies of digital public service interventions presented in the next section highlight the potential of interventions based on a basic information and communications platform, the mobile phone.

3. Digital initiatives and public services delivery in Sub-Saharan Africa: what do evidence-based studies tell us?

The uptake of mobile phone technology has facilitated the multiplication of digital innovations throughout the SSA. In West Africa, this uptake of ICTs has enabled the implementation of more than 400 operational digital initiatives (Briter Bridges, 2019) in 2019 across a wide range of sectors and countries (Figure 4). Fintech, Ed-Tech, health tech (mHealth), Agro-Tech, E-commerce and job platforms represent the sectors most affected by digital initiative expansion. However, only four countries – Nigeria, Ghana, Senegal and Côte d'Ivoire by decreasing order – contain more than 75% of

these initiatives. Therefore, the digital innovation process is unequally distributed throughout the region, mostly benefitting the four biggest economies of the area.

FIGURE 16. DIGITAL INNOVATION MULTIPLICATION IN WEST AFRICA.



Source: Briter Bridges, innovation maps, 2019. https://briterbridges.com/innovation-maps. Note: 442 digital innovations recorded. Some innovations have been simultaneously implemented in various West African countries. Among them, some are reported under the term "multi." Numbers in this figure are representative, not exhaustive, of the digital economy's expansion.

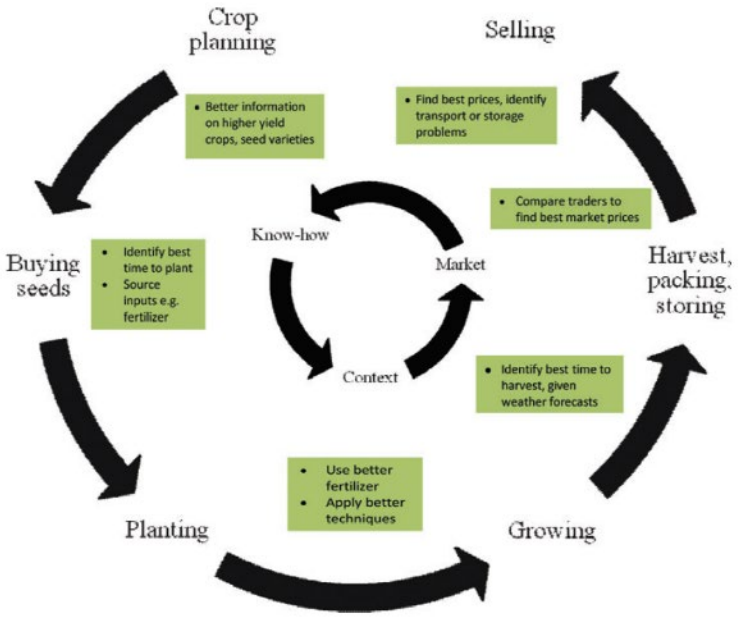
While this rise in digital innovations figures well for mobile and Internet technologies uptake and their contribution to the digital technologies takeoff in SSA and West Africa, their impact on public services provision and welfare depends on context, technology type, and the nature of the market failures they are intended to address (Aker & Blumenstock, 2014). We propose in this section a review of evidence-based studies conducted in West Africa and abroad that have emphasized a wide range of digital interventions in four areas of public service provision: agriculture, education, health, and financial services.

3.1. Information technologies and agricultural sector development

The agricultural sector's development and contribution to economic growth in SSA, including West Africa, is hampered by multiple structural constraints. These constraints include harsh climatic conditions, limited infrastructure coverage, rural and sparsely populated regions and markets, low literacy rates among adult populations, and the poor diffusion of agricultural market information and technologies (Aker, 2011; Aker et al, 2016a). Figure 17 below, drawn from Aker (2011) and reproduced from Mittal et al (2010), displays the different information needs associated with each stage of the agricultural production function, and the different areas of action of agricultural extension programs.[8] Figure 17 and Table 7 below synthesize how different types of ICTs may respond to informational needs and support agricultural market functioning, from crop planning to sales of produce in agricultural markets. Figure 18 provides information on 81 digital agricultural extension programs (Eagri) currently deployed in SSA (GSMA, 2019a) and stresses that most of these programs provide farmers with information on agricultural prices through text messages or the Internet. Appendix A reports examples of African extension programs identified by Aker (2011).

[8] Agricultural extension is defined as "the delivery of information inputs to farmers" (Anderson & Feder, 2007). Agricultural extension programs have been put in place to improve farmer access to agricultural market information and learning about agricultural techniques (Aker, 2011).

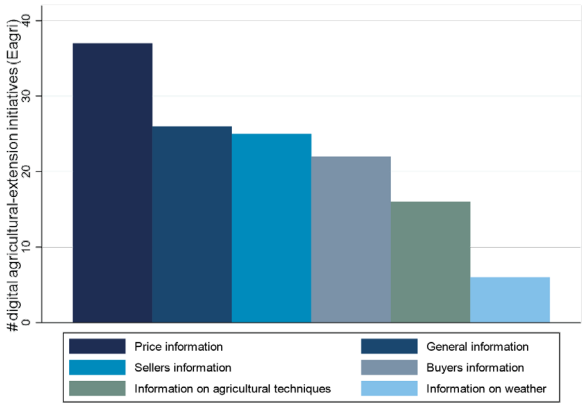
FIGURE 17. INFORMATION NEEDS ALONG THE AGRICULTURAL PRODUCTION CYCLE



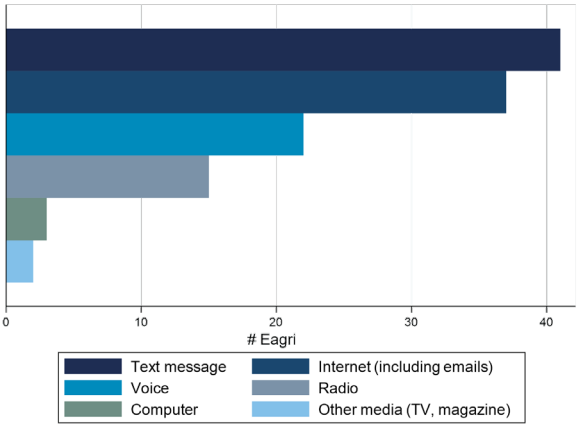
Source: Aker (2011), reproduced from Mittal et al (2010).

FIGURE 18. EAGRI DEPLOYMENT IN SSA, BY INFORMATION AND TECHNOLOGY TYPE.

(A) INFORMATION TYPE



(B) TECHNOLOGY TYPE



Source: GSMA Agritech deployment tracker, 2019a.

Aker (2011) and Aker and Mbiti (2010) point out the limits of traditional means of gathering information on African agricultural markets, generally based on personal travel, radios, newspapers or landline phone calls. Their effectiveness is indeed strongly limited by the size of the rural population, low adult literacy rates (especially in rural areas), and poor coverage of paved primary roads and telecommunications landline infrastructures. They also stress the constraints on Internet-based technology diffusion due to the low uptake of computers and smartphones and to the limited geographic coverage of 3G technology.

However, Aker (2011) identifies six levers by which basic mobile phone technologies, largely available throughout the African population, can improve access to agricultural market information. First, farmers can use mobile phones to obtain access to information on agricultural prices and technologies at low cost through their private social networks. Second, mobile-based communications technologies, such as

SMS, can increase the cost-efficiency of agricultural extension programs. This technology reduces the number of visits required by agricultural extension agents to transmit agricultural market information, increases the timeliness of information transmission, and enlarges the agricultural extension system's geographical outreach at low marginal cost (see Box 1). Third, mobile phone usage can reduce communication costs between farmers and buyers and farmers and traders, thereby fostering technology upgrading, reductions in price uncertainty, and improved input management and crop allocation across markets. This includes the use of technologies such as drones to obtain spatially explicit information on crop health and make precision applications of inputs such as fertilizer (see Box 2). Fourth, mobile phone technology can serve as a vehicle for the delivery of services that are complementary to agricultural activities. In particular, mobile phone diffusion among farmers facilitates the adoption of mobile money services (see section 3.4 on mobile money), which can in turn help them obtain insurance against weather or health shocks or to gain access to credit and saving services. Fifth, mobile phones can be used to improve the collection of information on farmers and extension agents, which can in turn increase the timeliness of market information exchanges and the accountability of extension agents. Lastly, mobile phones can help enhance the coordination between agricultural market actors, namely farmers, traders, extension agents, and research centers. In the following subsection, we review evidenced-based studies, focused on Niger and Ghana, which highlight the potential and the limits of mobile phone-based information systems for agricultural development.

3.1.1. Mobile phone access and grain market efficiency in Niger

Access to price information in landlocked and rural countries like Niger is often hindered by a lack of infrastructure and the long distances separating agricultural marketplaces. Such obstacles in communications induce important information costs, with serious consequences on producer and consumer behaviors and on agricultural market efficiency overall. Direct consequences of such market failures include spatial and time dispersion in commodity prices, reflecting supply and demand misallocation on commodity markets, which can sometimes lead to shortages that can have dramatic consequences on the welfare of rural populations. A better diffusion of ICTs could help farmers reduce information and transport costs and leapfrog missing transport infrastructures. We review below four related papers that illustrate how the adoption of basic ICTs such as mobile phones, and simple usage such as phone calls, may significantly improve the functioning of agricultural markets in Niger and the wellbeing of rural populations.

First, interesting evidence on the effect of mobile phone access on commodity producer behavior can be found in studies conducted by Aker (2010) and Aker and Fafchamps (2014). These studies provide evidence on the impact of mobile phone coverage on price dispersion across agricultural markets. In these markets, farmers produce, sell, and buy grains and transact with traders (retailers, intermediaries, semi-wholesalers, and wholesalers), and their produce is sent to various markets by transporters. Distances between markets considered in their study can vary substantially, from eight to more than 1,200 kilometers (Aker, 2010), inducing large transport costs and therefore large information costs. In a study on the impact of mobile phone coverage on grain price dispersion between markets, Aker (2010) estimates that the average price dispersion after a pair of markets benefits from mobile phone coverage decreased by approximately 10%, corresponding to a reduction of 2.5-3.5 CFA/kg. Aker (2010) also highlights that this effect is stronger when markets are remote from each other, and when they are connected by unpaved road infrastructures, thereby supporting the theory that the benefits of ICTs are larger in isolated areas.

TABLE 7. INFORMATION AND COMMUNICATIONS TECHNOLOGIES AND AGRICULTURAL MARKET FUNCTIONING

Extension Function	Radio	TV & Video	Cell phones	Feature & Smart Devices	Computer & Internet
	Identifying farmers' problems and opportunities – What do they need and want?				
Diagnose problems	Some potential if dealing with general problems, or if capacity for interaction and expertise available	Visuals are very helpful, as "seeing is believing." Even better if combined with ways to receive feedback.	Some potential if farmers can call or text in and sufficient expertise is available.	Additional potential than a simple cell phone as it enables web or app access to special diagnostic tools.	Good comprehensive diagnostic tools are available
Collect information	Some potential if capacity for interaction		Can use for data collection.	Good for data collection with GPS.	Some potential if internet available.
	Promoting behavior change – What is practical and relevant to meet needs?				
Raise awareness of general opportunities or needs; convince farmers to try something new	Very good especially with persuasive programming	Visuals are usually very helpful, as "seeing is believing"	Is an option if users are registered to receive such messages (SMS)	Is an option if users are registered to receive such messages (SMS, email)	Is an option if users are registered to receive such messages (email)
Provide specific information needed for change. What is involved? What are the benefits/ demonstrate or train?	Some potential – but limited information delivered. Can be enhanced with call-in.	Good option, as "seeing is believing"	Potential if farmers can call or text in and sufficient expertise is available	Additional potential than a simple cell phone as it enables web access and video playback.	Good option for intermediaries to seek information and videos.
Facilitate access to credit and inputs	Can be used to inform about available services, but only one-way communication	Can be used to inform about available services, but only one-way communication	Mobile banking and direct negotiation with suppliers	Mobile banking and direct negotiation with suppliers	Mobile banking and direct negotiation with suppliers
Link farmers to markets	Good for providing general price reports		Access to price information (call-in, subscription)	Can bring potential buyers and producers together; access price information	Can bring potential buyers and producers together; price info.
	Collect feedback – How can each step be improved?				
Collect and respond to farmer feedback	Good if producers can call in and sufficient expertise is available	Good if producers can call in and sufficient expertise is available	Some potential if farmers can call or text in and sufficient expertise is available	Good option for intermediaries to seek information (if optimized for smart devices)	Good option for intermediaries to seek information
Assist with business planning	Some potential	Some potential		Simple farm management apps; recordkeeping	Farm management tools; recordkeeping

Source: http://www.fao.org/e-agriculture/blog/icts-and-agricultural-extension-services

In the same context, Aker and Fafchamps (2014) further the analysis initiated by Aker (2010), stressing the heterogeneous effects of mobile phones on price dispersion, depending on the storable nature of the commodity produced. They also unveil the mechanisms through which the convergence in commodity prices is achieved. In fact, they study the price dispersion of three commodities – millet, sorghum, and cowpea – and find that mobile phone coverage reduces price dispersion of cowpea, a semi-perishable good that cannot be stored easily, by 6 percent. By contrast, price dispersion of millet and sorghum, commodities that are less perishable and more easily storable by farmers, are not affected by the introduction of the new technology. The supply of less-storable commodities like cowpea is less subject to intertemporal arbitrage by producers, and therefore prone to spatial supply misallocation when information on prices is missing and transportation costs are high. In support of this mechanism, they observe cowpea price increases (decreases) in surplus (penury) markets after the rollout of mobile phone coverage, which supports the hypothesis that mobile network extension increased market efficiency by improving information on quantities supplied and demanded on covered markets.

Second, while the two earlier studies evaluated commodity price convergence in markets covered by the mobile network and focused on producer behaviors, Tack and Aker (2014) propose an explanation for this mechanism based on Nigerien grain traders' behaviors. They build a theoretical model emphasizing how the reduction in search costs induced by mobile phone usage can increase traders' reservation prices, thereby extending the geographical scope of market information searches. To illustrate the fall in search costs resulting from mobile phone introduction among traders, Tack and Aker compare the average travel cost to a 65 km-distant market, consisting of a 2-4-hour roundtrip travel time, to the cost of a two-minute phone call. Considering a 500 CFA (1 USD) daily wage as a benchmark salary, they conclude that information search costs would drop by 50% after the introduction of mobile phone technology.

Using data on grain traders and markets, the authors find empirical support for this last prediction of their model, as they evidence a positive effect of the duration of mobile phone coverage[9] on the number of markets subject to and the number people consulted for price information search by traders. In fact, a longer duration of mobile phone coverage is associated with a better use of the technology by traders. Traders might also derive greater utility from using mobile phones from an extended network of mobile phone users[10]. Overall, their results support the existence of a dynamic effect of mobile phone coverage on trader search behaviors, leading to a yearly 5-6% increase in the number of markets investigated and the number of market contacts solicited. Interestingly, they find that this relationship between mobile coverage duration and traders' information search intensity is convex, meaning that this effect increases with time.

Third, another study conducted by Aker and Ksoll (2016) reveals the results of a randomized control trial (RCT) implemented in two rural regions of Niger between 2009 and 2011, consisting of an adult education program aimed at teaching students how to use mobile phones. Initially designed to assess how mobile phones are a technology that can improve learning outcomes (Aker & Ksoll, 2019; Aker et al, 2012; see also subsection 3.2), the authors use this field experiment to study how the diffusion of basic communication technologies can affect farming decisions. They find that households which benefitted from mobile phone use classes were more likely to diversify their crops when compared to households who did not attend such classes, and they were also more likely to engage in crop sales. They also find that these effects were stronger when the beneficiary of the program was a woman, was not familiar with mobile phone technology prior to the program, and was located in a village without a commodity market. The authors argue that the improved access to market information induced by the

[9] i.e. the number of years passed since mobile network arrival in a given market.

[10] as recently evidenced in the Rwandan context by Bjorkegren (2019)

usage of mobile phones could have increased household bargaining power, thereby increasing their inclination to engage in the production and sale of new crop varieties. This communication technology could also have fostered the sharing of agricultural practices between farmers and the farmers' involvement in new types of crops. Moreover, this diversification of agricultural production resulting from improved access to mobile telephones could have reduced rural household exposure to risks and increased their ability to select crops for commercial specialization according to market conditions (Fafchamps, 1992; Dorsey, 1999; Kurosaki & Fachamps, 2002; Besabih & Sarr, 2012).

Overall, these four studies provide insightful evidence on the positive effect of simple information technologies such as mobile phones on the functioning of agricultural markets in rural areas of SSA. In fact, these studies support that the diffusion of mobile phones among Nigerien farmers and traders has reduced information asymmetries resulting from the large distances between economic agents and markets, and therefore addressed a key market failure prevalent in rural Niger. By showing that mobile phones represent a useful alternative to traditional information search mechanisms (Table 7), they also provide a concrete illustration of the leapfrogging potential of digital technologies in a context of missing road and landline infrastructures.

3.1.2. ICT-based information provision and farmer behavior in Ghana

Despite a higher penetration of mobile phones and a better coverage of mobile networks in rural Ghana as compared with rural Niger, agricultural communities in Ghana also face commodity price uncertainty, agricultural market inefficiency, and low technology adoption. As in Niger, farmers must cover large distances in order to reach agricultural marketplaces, transportation costs are high, and means of communication are not sufficient enough to obtain production and price information in an efficient manner. The first paper emphasizes the potentially strong network effect of agricultural information sharing on technology diffusion among pineapple famers in southern Ghana. The second paper highlights the benefits of a centralized SMS-based market information system on farmers' bargaining power in northern Ghana. In the same geographical context, the third paper compares the effect of multiple sources information search on market participation rates of farmers.

First, an important study of an agricultural extension program for pineapple cultivators from southern Ghana in 1996-1998, conducted by Conley and Udry (2010), stresses the potentially strong network effects of communication technologies on the adoption of an agricultural innovation. The authors investigate the role of agricultural extension through social learning for the diffusion of new agricultural technologies among pineapple cultivators. Exploiting a rich dataset on information exchanges between farmers, they identify informational links and stress how they foster technology spillovers. Surveyed farmers were asked whether they sought advice about their farm and if yes, to confirm or refute any information links with other respondent farmers. Based on this matrix of informational connections, they construct a metric measuring the respondent's positive or negative feedback on input use efficiency that they obtained from farmers to whom they were linked. They then conduct an analysis of the impact of this measure on the probability of changing the farmer's production technology. They find that a pineapple cultivator is likely to modify their use of fertilizer when they have negative feedback on historical usage of fertilizer and positive feedback on alternative uses. By contrast, they find that a cultivator is unlikely to change their technology when they have positive feedback on historical usage of fertilizer and negative feedback on alternative uses.

Therefore, this research points out that social learning is a critical mechanism through which ICT spillovers could operate. This evidence indirectly suggests that ICTs can promote adoption of innovations and improve productive efficiency by facilitating communication of information between producers (Aker, 2011; Aker et al, 2016a). However, while the positive role of ICTs on adoption of

innovations has been stressed for farmers in Ecuador (La Rochelle et al, 2019) and India (Cole & Fernando, 2012; Fu & Akter, 2016), and for the private sector in developing countries (Paunov & Rollo, 2015, 2016), evidence on such positive externalities in Sub-Saharan Africa is still scarce.

Second, a study conducted by Courtois and Subervie (2014) in rural northern Ghana evaluates the potential benefits for farmers of a centralized market information system (MIS) – the **Esoko services**[11] – relying on mobile phone networks to diffuse agricultural market information. Transportation and information search costs, higher in the northern part of Ghana (Zanello et al, 2014), explain why traders play an important role in the Ghanaian agricultural system, which consists of buying supplied quantities at farmgates and selling them at farmer marketplaces. In such an environment characterized by information asymmetries on prices paid at different marketplaces, improving Ghanaian farmers' access to information is expected to increase their bargaining power and to reduce transaction costs.

Because of price information asymmetries, farmers have to choose between selling their produce at the farmgate to traders and receiving lower prices for their crops or selling their produce at the marketplace at higher prices but incurring larger transportation and price information search costs. Esoko is a system implemented in 2005 to collect information on wholesale prices across agricultural markets and disseminate this information to Esoko subscribers by text messages. Centralized systems of public agricultural information dissemination via text messages have indeed proven to be more effective and cheaper than extension visits or radio communication and have enabled the provision of timely and context-specific information over a large geographical scope (Aker, 2011; Aker et al, 2016a). However, the benefits of such systems rely on the size of the users' network, i.e. the number of mobile phone owners and Esoko subscribers. The Eastern Corridor Agro-Information Center (ECAMIC) project was implemented in 2008 to facilitate the adoption of subsidized mobile phones within farmer cooperatives and to offer these farmers training and temporary access to Esoko services.

Their results stress that farmers who benefitted from the ECAMIC project observed 10.4% and 7.3% increases in sales prices obtained at the farmgate for their maize and groundnut crops, respectively.[12] They notably show that this increase in prices results from a transfer from traders to informed farmers, with no consequence on uninformed farmers' surplus. Therefore, the dissemination of price information through an MIS has increased famer bargaining power and was welfare (Pareto) improving for farmers. However, despite the net benefits derived from the adoption of the MIS technology, the authors stress that only a small fraction of African farmers has used a mobile-based MIS. The reasons for the rather low diffusion of this technology remain yet to be revealed.

Third, in a study conducted on a community of grain and legume farmers in northern Ghana, Zanello et al (2014) study the effects of ICT diffusion on farmer decisions to sell their produce at the farmgate or at marketplaces. The authors exploit a novel and rich dataset on farmer transactions and use of ICTs to obtain price information at various marketplaces. They expect the use of ICTs to reduce farmer information costs, which are fixed costs independent from sold quantities, and to increase farmer inclination to sell directly at marketplaces. They separate the effects of different information sources – namely, radio, phone calls, combined radio and phone calls, word of mouth, neighbors, and extension agents – and find that farmers' inclination to sell at marketplaces rather than farmgates is positively related to the presumed reliability of these market information sources.

[11] Appendix A presents a list of existing agricultural information dissemination services in SSA

[12] In a study conducted in India, Fafchamps and Minten (2012) show that farmers who benefitted from a comparable SMS-based agricultural information system did not receive a higher price at the farmgate but were more likely to travel to more remote markets.

The results of this study show that single-source (including ICT-based) information searches are negatively related to the probability of bypassing traders and selling at marketplaces. By contrast, combining phone calls and radio or resorting to agricultural extension agents, expected to provide trustworthy agricultural market information, are found to increase the probability of selling at marketplaces. The authors conclude that when market information is deemed reliable, farmers are likely to incur transportation costs to sell their crops at higher prices in marketplaces; whereas when information is drawn from less reliable sources, farmers use it to negotiate higher prices with traders at the farmgate. An interesting insight from this study is the importance of mixing ICT services, here the combination of radio and mobile phone usage, which are complementary and are more effective at reducing market information asymmetries by reinforcing the credibility of information.

3.1.3. Main lessons

To summarize, this sample of studies conducted in rural areas of Niger and Ghana confirm that the adoption of communications technologies such as mobile phones can increase agricultural market efficiency through multiple mechanisms. Specifically, these technologies can improve farmer production and selling decisions, the coordination of input and output supply chains, their bargaining power with traders, and foster the adoption of efficient or innovative production technologies (Aker, 2011; Aker et al, 2016a). However, as pointed out by Aker et al (2016a), to be effective, ICT-based applications for the agricultural sector have to take into consideration various contextual factors. Such factors include the type of informational asymmetry incurred (price uncertainty, geographical outreach of market price information search, information on agricultural techniques, etc.), the existence of market failures in related markets (e.g. insurance or credit markets), the type of crops cultivated and sold on markets, or the sociodemographic characteristics of farmers (literacy, gender, ethnicity, revenue).

Moreover, one interesting insight drawn from Zanello et al (2014) is that ICTs will empower farmers vis-à-vis other market agents inasmuch they can provide them with trustworthy information. In a decentralized private information setting, the reliability of market information depends on the farmers' information network size, i.e. the number of information connections from which famers can extract information. In a centralized public information setting, including those promoted by agricultural extension programs such as an MIS, the power of information seems to depend not only on ICT adoption but also on the adherence to traditional agricultural extension programs.

In a nutshell # 1: Information technologies and agricultural sector development

Technologies

Mobile phone

Usage

Phone calls

Text messages

Stakeholders

Farmers, traders, agricultural extension agents

Mechanisms

Reduction of information asymmetries on agricultural prices and production technologies through information cost reduction

Improvement of information quality: reliability, timeliness and geographical outreach.

Impacts

Reduced commodity price dispersion

Improved spatial and intertemporal production and selling arbitrage

Increased bargaining power yielding producer surplus

Innovation diffusion and productive efficiency

Factors of success/failure

Penetration of the technology (mobile phone, market information system)

Information quality (single, multiple-sourced information)

Farmer sociodemographic characteristics

Box 1. Digital for agricultural extension prototype in Sierra Leone: insights from the Digital Farmer Field School technology

Context

Technology and information dissemination are central agricultural extension activities. These activities build on the "bridging" function of extension organizations, consisting in linking farmers to each other and to other rural agricultural sector stakeholders: traders, (financial) service providers, consumers, NGOs, rural organizations, input suppliers, etc. In West Africa, the Farmer Field School (FFS) methodology is among the most common of agricultural extension approaches. **FFS provides farmers with theoretical and experiential learning tools – combining concrete experiences, observation and reflection, generalization and abstract conceptualization, and active experimentation - to help them make optimal choices of production methods** in a way that best organizes themselves and their community.

In Sierra Leone, in the context of restrictions on gathering in groups of more than five people during the West African Ebola outbreak in 2014-2015, a prototype of a **Digital Farmer Field School (DFFS)** was designed and tested to maintain **farmer training programs for cocoa production certification, providing an innovative learning environment**. The DFFS model was based on the following two design principles: 1) **User experience** (UX), with small groups of farmers interacting with a tablet in offline mode, exchanging information and learning together about cocoa production and certification, and; 2) **User interface** (UI), with a group of seven animated farmers led by the female animated cocoa farmer Fatu guiding users through the DFFS learning experience on the application.

Technology

The objective of the DFFS was to create a **mechanism for continued delivery of the cocoa certification program** launched in 2014 by Jula Consultancy and the supply chain NGO FairMatch Support. This program enables smallholder cocoa farmers to obtain certification from Utz, Fairtrade, and the Rainforest Alliance, thereby qualifying them for the higher premium price paid for certified cocoa and theoretically leading to increases in income and improved livelihoods. The DFFS prototype contained several unique features to ensure maximum effectiveness, including a back office built into the app enabling users to directly call agricultural extension agents or send them questions as recorded messages if phone service is not available. All FFS and certification content is delivered via video or animation with voiceovers in the Krio language, taking into account low literacy rates and technology proficiency among intended beneficiaries. Tablets were chosen for the prototype test because they were less expensive than smartphones, and the larger screen size made it easier for older farmers to see.

Content included principles of Integrated Pest Management (IPM), crop planning, management, agricultural practices, social practices, certification information, and environmental practices, among others. The app also included a method for farmers to take pictures with the tablet and document their cocoa farms, including troubleshooting pests, diseases, and other potential problems. Most farmers interacted with the DFFS in groups, similar to the collaborative nature of a traditional FFS, and participated in the process of learning how to use the tablet and the DFFS interface together.

Impact

Farmers, trainers, and extension agents overall reported that using the **DFFS was a positive experience** and enabled them to continue meeting with their existing FFS groups even in light of the group meeting restrictions during the Ebola outbreak. **However, the DFFS was never developed beyond the prototype stage due to lack of funding, and more work is necessary to turn the digital training platform into a concrete reality,** even though the context of the Ebola outbreak has now passed. Initiatives such as the DFFS may be more interesting than ever now given the current context of the COVID-19 pandemic. The authors note that while the UX may be transferrable to other contexts, the UI would have to be adapted to each specific context, including beneficiary demographics and program objectives. Another challenge lies in optimizing image and animated content to maximize visual learning outcomes, as one previous study has shown mitigated results in relation to visual learning from ICT agricultural training (Witteveen & Lie, 2012). Witteveen et al (2017) state that **digitizing agricultural training programs should be seen as a way to scale up initiatives that are already successful on the ground instead of a way to fix failing or lacking initiatives**. The replicability of this prototype is currently being tested on Mongolian nomadic herders through the Digital Herder Service Center (DHSC) (Witteveen et al, 2017).

Sources

Witteveen, L.M., Lie, R. (2012). Learning about "wicked" problems in the global south. Creating a film-based learning environment with "Visual Problem Appraisal". MedieKultur J. Media Commun. Res. 28, 81–99.

Witteveen, L., Lie, R., Goris, M., & Ingram, V. (2017). Design and development of a digital farmer field school. Experiences with a digital learning environment for cocoa production and certification in Sierra Leone. Telematics and Informatics, 34(8), 1673-1684.

Box 2. Exploring the adoption of drones in agriculture in Benin: Smallholder farmer perceptions and willingness to pay for drone services.

Context

Although agriculture is an important part of the economy and rural livelihoods in Benin and other developing countries in Sub-Saharan Africa, **the sector is plagued by market failures such as imperfect information and high transaction costs,** leading to reduced agricultural productivity, low resilience of smallholder farmers to climate change-related shocks, land degradation and ecosystem damage, and suboptimal management of climate risks. These problems are caused in part by lack of sufficient machinery and tools, sparse road and infrastructure networks, poor agricultural input provision schemes, insufficient access to improved seed varieties and irrigation technologies, and poorly developed value chains for key commodities. These issues pose a real threat to the food security of smallholder farmers and other populations in Benin who depend on their produce for sustenance.

Technology

As a means for addressing the inefficiencies inherent in the country's agricultural sector, the Beninese startup Global Partners teamed up with the Technical Centre for Agricultural and Rural Cooperation (CTA) in the Netherlands and the University of Kentucky in the United States to provide **drone-based agricultural monitoring services to smallholder rice farmers through use of a multispectral imaging device mounted on a drone**. Global Partners (2018) offered the drone-based service farmers to assist them in monitoring the health of their crops on a spatial scale as well as evaluating nutrient needs and producing precision fertilizer and pesticide application recommendations. Global Partners also conduct a randomized controlled trial of the effect of drone use on agricultural outcomes and willingness to pay among smallholder rice farmers in the Glazoué commune of Benin. At the conclusion of the project, 232 rice farmers were shown images of drones, images taken by drones, and explanations of their advantages in agricultural production. Farmers were also asked how much they were willing to pay for various services offered by the drones.

Impacts

Regarding smallholder Farmer Perceptions, 53 percent of the respondents indicated that they found the drones to be very interesting, while 46 percent found them to be interesting, showing that almost all surveyed farmers had a positive perception of drones and their utility in increasing agricultural yields and optimizing input applications. Forty-five percent of respondents stated that they found the ability to move freely and uninhibitedly throughout the field when conducting crop monitoring to be the most interesting aspect of drone usage in agricultural production. Thirty-seven percent of respondents declared that use of drones in precision pesticide applications was most interesting to them, while 12 percent indicated that precision fertilizer applications interested them the most.

In terms of willingness to pay, the majority of survey respondents indicated they were willing to pay less than 5000 FCFA/ha (8.60 USD/ha) for any given drone-based service such as those mentioned above. For example, the mean willingness to pay for identification of pest attacks by drone was 3,345 FCFA/ha (5.75 USD/ha), compared to 8,510 FCFA/ha willingness to pay for the same service delivered by human power (14.64 USD/ha). The same was true for fertilizer spreading, with farmers willing to pay 2,597 FCFA/ha (4.47 USD/ha) for the drone-based service compared to 7,500 FCFA (12.90 USD/ha) for the traditional human-powered service. This lower willingness to pay for the drone-based services could be due in part to the farmers' perception of the drone-based work as requiring less manpower and less resources, thus assuming that it should cost less than paying laborers to complete the same tasks. For pesticide applications, the amounts were similar, with farmers indicating they were willing to pay 3,391 FCFA (5.83 USD/ha) for the drone-based service and 3,218 FCFA/ha (5.54 USD/ha) for a traditional human-powered service. This willingness to pay slightly more for the drone-based pesticide applications in this instance could be due to the farmers realizing that precision-based applications mean less overall pesticide used and less money spent on inputs, as opposed to uniform applications using the traditional method.

Overall, the results of the study showed that **Beninese rice farmers had a positive perception of drone usage** in agricultural crop management, including for spatial crop quality control, identification of nutrient needs, and precision application of pesticides and fertilizers. However, smallholder farmer participants indicated that they **expect to pay less for drone-based services than they traditionally pay for manpower-based services**. As such, farmers were found to value awareness campaigns, reduced costs, and permanent availability of the drone-based technologies, and these principles should be applied in order to strengthen adoption and uptake rates.

Source

Global Partners. (2018). Exploration de l'adoption des drones en agriculture au Bénin : perceptions et consentement à payer des petits producteurs pour les services de drones. Global Partners – Shaping the Digital Revolution in Agriculture in Africa. Accessed 12 June 2020.

3.2. Information technologies and educational outcomes

In SSA, the context of poor school network coverage, lacking human and financial resources for education, and missing road and telecommunications infrastructures has given telecommunications technologies – like radio, TV, mobile phones and now smartphones and tablets – an important role in the dissemination of knowledge, the monitoring of educational outcomes, and teacher performance (Aker, 2017; Menascé & Clément, 2017). However, the integration of ICTs in learning programs of schools is hampered by the unequal coverage of mobile Internet networks and recurring power outages, especially in rural areas.

Between 1999 and 2011, primary school enrollment has shifted from 82 million to 136 million pupils, increasing the net enrollment ratio from 58% to 77% (Menascé & Clément, 2017). Despite the noticeable progress made in terms of primary school attendance, improvement in learning outcomes is still hindered by classroom overcrowding, teacher absenteeism and textbook shortages. In addition to the problems faced by children at school, populations throughout SSA also suffer from lack of basic reading and numeracy skills among adults. According to the World Bank (2020), the literacy rate in Sub-Saharan Africa was only 65% on average and even lower in West African countries such as Senegal (52%), Liberia (48%), Sierra Leone (41%), Burkina Faso (41%), Mali (35%), or Niger (30%). The research presented below provides evidence on how ICTs can contribute to schooling performance by improving literacy and numeracy skills and enabling better monitoring of school administrations.

3.2.1. School e-learning programs: mixed evidence from developing countries, few African initiatives.

Most empirical studies of the effects of digital technologies on learning outcomes in primary and secondary schools of developing countries are focused on computers/laptop-based technologies and provide rather mixed evidence.[13] In SSA, while traditional communication technologies, such as the radio or the TV, have been mobilized to support national educational programs in Côte d'Ivoire, Senegal and Niger (Menascé & Clément, 2017), initiatives using new digital technologies are scarcer when compared to other developing areas. In particular, computer-based learning programs are undermined by the low penetration of computers and the limited landline infrastructure coverage in Sub-Saharan Africa. These handicaps make this technology rather unfitted for large-scale programs, especially in large rural countries such as Niger, Mali or Burkina Faso. In 2016, the average proportion of households with a computer was indeed approximately 12.5%, and it was only around 3% in landlocked countries such as Mali, Burkina Faso or Niger (ITU, 2019). Moreover, only 44.5% of the SSA population had access to electricity in 2016 (World Bank, 2020), and this number is even lower at 22.6% for rural areas, which seriously constrains new ICT-based learning technology (Menascé & Clément, 2017). In 2005, the "One Laptop Per Child" initiative was launched with the aim of providing African schools with low-cost energy-saving computers, including access to a pedagogical platform. Only a few dozen local projects have nevertheless been set up within this initiative in West Africa[14], and assessments of their impact on education outcomes are still lacking.

Nonetheless, the recent uptake in the penetration of new mobile technologies such as smartphones or tablets across the continent raises new prospects for education programs based on digital technologies. Mobile devices can also be combined with more traditional forms of media such as radio or television to provide educational content in a very effective way (Menascé & Clément, 2017; See Boxes 3 and 4). Because of the low replication costs of electronic educational content, low-cost nomad devices such as

[13] See Banerjee et al (2007), Linden (2008), Lai et al (2013, 2015), Beuermann et al (2015), Malamud and Pop-Eleches (2011)

[14] See the interactive maps provided on the project's website: http://olpcmap.net/.

the "XO" tablet can be used as a support for academic content and effectively replace textbooks or other school materials, especially where public funds dedicated to education might not reach their intended beneficiaries (Bold et al, 2017). In fact, the Public Expenditures Tracking Surveys (PETS) conducted in Ghana, Tanzania, Uganda, and Zambia between 1991 and 2004 stress that leakage of public resources in the education sector ranges from 49% to 87% of initial public funds dedicated to schools (Gauthier & Reinikka, 2007). In particular, the PETS conducted in Zambia in 2001 revealed a remarkably high ratio of students per textbook in primary and secondary schools, ranging from 5 to 7 students per textbook (Berryman & Caillaud, 2017). Unfortunately, evidence-based analyses of such programs supporting access to pedagogical electronic content through digital devices is scarce.

In India, Banerjee et al (2007) have conducted field experiments in urban schools to study the short-term impact of a computer-assisted learning program and highlight a positive impact on pupils' math scores. They however stress that the scaling-up of such a program would not be as cost-effective as other learning programs, which are less intensive in digital technologies while yielding comparable educational outcomes. A similar study has been conducted in Beijing schools by Lai et al (2015) and finds similar evidence on the short-term benefits of computer-assisted learning for students' numeracy skills, with however a stronger effect for the less-educated children. In India, Linden (2008) shows in a randomized experiment that computer-based learning programs are effective at improving school performance when they are set up as an out-of-school tool, complementary to standard in-class teaching. By contrast, the author finds that such programs are associated with lower student performance when used as a substitute for in-class teachers. Other studies, such as Beuermann et al (2015) and Cristia et al (2012) conducted in Peru, find no effect of computer-assisted programs on children's literacy and numeracy performance, but a positive effect on children's general cognitive skills (Cristia et al, 2012). Other studies, such as that conducted by Malamud and Pop-Eleches (2011) in Romania, even find a negative effect of such programs on educational outcomes. To sum up, empirical evidence suggests that computer-assisted learning programs are costly and do not necessarily yield the expected outcomes in terms of children's literacy and numeracy.

3.2.2. School e-monitoring programs: evidence from Uganda

If digital technology's impact on access to and assimilation of educational content is mixed, mobile technologies have proven to be effective monitoring tools for school system stakeholders. Reinikka and Svensson (2011) have provided insightful evidence on the benefits of public access to information on the governance of public school administration and school performance. The authors study the impact of a program implemented in 1997-1998 by the Ugandan government to tackle widespread corruption in the education sector. This program consisted of publishing publicly and on a regular basis information on public funds allocated to instructional material and non-wage spending in district school administrations through newspapers. This campaign was intended to reduce the capture of public resources and improve school enrollment and learning outcomes through improved parent and head teacher monitoring of local administrations. In fact, the resulting increase in school funding was expected to improve teaching quality, to reduce household educational expenditures, and to increase school attendance. The authors combined data drawn from PETS conducted before (1996) and after (2002) this campaign with data on enrollment and test scores drawn from administrative records. They exploit the school's distance to the closest newspaper outlet after the campaign kickoff in 1997 to identify the impact of the program on school funding management and educational outcomes. They find that improved access to school funding information, proxied by the school's distance from a newspaper outlet, increases the share of funds reaching schools and leads to improved school enrollment and average exam scores. While this study does not strictly address the direct contribution of a digital information technology to school management and pupil performance, it indirectly highlights the

potential benefits of improved access to information on school administration using ICTs. In fact, digital initiatives such as the "Pret-à-Payer" program in Benin – a mobile-money-based school-fee payment system (see subsection 2.2.3) – have realized the power of information in public services and have included a digital information platform which allows teachers, school administrators and parents to obtain timely access to school financial records.

In addition to administration governance quality, teacher quality is also recognized as a critical factor affecting pupil performance at school. Recent studies stress that schools in Sub-Saharan Africa are characterized by high teacher absenteeism, insufficient teacher knowledge, and subpar teaching skills (Bold et al, 2017). In fact, using survey data from seven African countries[15] covering 16,543 teachers from 2,001 schools, Bold et al (2017) find that on average, 44% of teachers were absent from class and that less than a half of the scheduled teaching time was actually spent teaching. They also found that only two thirds of surveyed teachers were able to master a 4th-grade curriculum, and only one quarter of teachers could do so in Nigeria. Lastly, the same study revealed that 47% of teachers were able to understand a factual text and only 11% of them had minimum general pedagogical knowledge, consisting of translating information processed from the factual text into teaching. In conclusion, the authors attribute this poor performance to the low selection standards and low quality of teacher training programs, and to the poor (monetary and non-monetary) incentives for delivering high-quality teaching. Therefore, in this context, digital innovations targeted at monitoring teachers, improving their training, and assisting them during their classes could produce significant benefits for primary and secondary educational sector performance (see Box 5).

Regarding the potential benefits of digital monitoring on teacher absenteeism, Cilliers et al (2018) provide interesting insights into the effect of different digital monitoring settings on teacher absenteeism and pupil performance in Uganda. This study consisted of assessing the impact of a mobile phone-based monitoring system, allowing head teachers to report teacher absenteeism via SMS on a digital platform. Mobile-based decentralized monitoring was justified in a context of remote school locations, poor transport infrastructure, and limited resources for inspections. One hundred eighty rural public primary schools from six districts were randomly assigned three monitoring system settings. In one setting, school head teachers were asked to send reports on monthly teacher attendance via SMS to a centralized information platform. In a second setting, a bonus payment was made to teachers who were reported to have regularly attended classes over the month. The third setting was the control group, which was not subject to any monitoring or bonus payment systems.[16] Once reports were sent by the head teacher or by students' parents via SMS, the information was aggregated, processed, and sent back to the community. Based on this information, teachers from selected schools were given a monthly bonus payment equal to 12% of the teacher's monthly salary if they were reported as regularly present over the month. Their results stress there is an amplifying combined effect of both SMS-based local monitoring and bonus payments to teachers, compared to SMS-based local monitoring alone and the control group, which resulted in increased teacher attendance, increased student enrollment, and improved information quality (measured in terms of report frequency and unreported absences). Their results, however, point to the ineffectiveness of SMS-based local monitoring without a bonus payment system for improved performance in relation to previous outcomes.

[15] Kenya, Mozambique, Nigeria, Senegal, Tanzania, Togo and Uganda.

[16] In a former version of the paper, the experiment consisted of five groups, in which head teachers (HT) or pupils' parents (PP) could assume the monitoring function (Cillier et al, 2014): HT monitoring with payment, HT monitoring without payment, PP monitoring with payment, PP monitoring without payment, and the control group.

3.2.3. ICTs and adult learning: evidence from Niger and Burkina Faso

While policies and programs aimed at improving primary and secondary school enrollment rates, learning outcomes, and governance are expected to impact economies in the long run by creating an educated and skilled workforce, adult literacy and numeracy has an immediate impact on development outcomes. In 2018, 35% of the Sub-Saharan African population ages 15 and above was unable to read and write a short, simple statement about their everyday life (World Bank, 2020). This high rate of illiteracy suggests that adult education programs, building on digital technology diffusion, could help fill the adult literacy gap by improving their learning abilities. We review below some evidence on the role of ICTs in improving adult learning from Niger (Aker et al, 2012; Aker & Ksoll, 2019) and Burkina Faso (Maredia et al, 2018).

Aker and Ksoll (2019) present the results of an adult education program aiming to increase teacher accountability and improving adult basic numeracy and literacy skills in rural Niger. In this regard, Niger's adult literacy rate was approximately 30% in 2012 (World Bank, 2020), which is among the lowest literacy rates in SSA. As in many West African countries, the Nigerien school system suffers from low instructional quality and high teacher absenteeism (Aker et al, 2012), partly explained by the difficulty of observing teacher effort, especially in remote rural areas where transportation infrastructure is lacking and public institutions are failing. In this context of high monitoring costs and limited monitoring resources, mobile technology can be an effective tool for increasing teacher accountability by facilitating communication between education program stakeholders (students, parents, heads of villages) and the school administration.

This education program consisted of a 10-month numeracy and literacy instruction program, spanning 2014-2015 and implemented in 131 villages. Villages were randomly assigned three different intervention settings, differing according to the teacher monitoring technology. The first setting was comprised of regular physical visits to treatment villages by government officials and NGO staff. In the second setting, villages received the same visits with the addition of a mobile phone intervention. This intervention consisted of making weekly calls to the village teacher, the village chief, and two random students[17] and asking them information about school functioning – the number of classes held, the number of teaching hours by class, and the number of students attending classes. The third setting was a village control group, without any education program, visits, or phone calls. To identify the impact of the intervention on educational outcomes, the authors combined data on adult student test scores, behaviors, and motivation with household survey data and data on teacher qualification, efforts, and sociodemographic characteristics.

Their results support that the education program increased adult math and reading z-scores, and that this positive effect was significantly higher in villages with the mobile phone intervention. Six months after the intervention, test scores were higher only for adults having received a telephone call, when compared to the control group, suggesting sustained benefits from mobile phone-based monitoring mechanisms. Among the mechanisms that can explain this evidence, the authors find that teachers in villages with mobile interventions displayed higher attendance logs and higher competency scores, while students were less likely to drop out of school. While the authors emphasize the potential of using phone calls as a monitoring technology to support adult education programs, they also underline the very contextual

[17] There was no mobile phone distribution prior to the intervention, so that if a teacher, chief, or student did not have a phone, they were contacted by a neighbour or a relative. In the second year of the intervention, only teachers were called in a subset of villages.

nature of this mobile intervention (a French-speaking low-literacy Sahelian country), and stress ways of improving the intervention such as bonus payments conditional on teaching outcomes.

In another study conducted in rural Niger, Aker et al (2012) emphasize the role of mobile phones as a learning engine for improving adult literacy and numeracy. In 2009, an adult education program was implemented in 134 villages located in the Dosso and Zinder regions to provide instruction to 6,700 adults over a two-year period. This program consisted of a mobile phone intervention – the *Alphabétisation de Base par Cellulaire* (ABC) – consisting of adding a learning module on how to use mobile phones to the standard education program. This additional mobile intervention, implemented randomly in half of the 113 surveyed villages, was based on the premise that learners using mobile phone technology would practice and improve their literacy and numeracy skills through phone calls, text messages, and mobile money transactions. It was also intended to increase education returns by improving mobile phone user knowledge of agricultural and labor market conditions and facilitating money transfers between individuals.

This impact analysis consisted in comparing adult learning outcomes in ABC villages with those in non-ABC villages. In each village, eligible applicants were identified according to whether they were literate or not, their membership in a producer association, and their willingness to participate in the program. Data from applicant math and writing tests were combined with student, household, and teacher survey information before and after program implementation. The authors found that the joint ABC and adult education program increased both writing and math test scores for students, and that these benefits persisted one to two years after the program's implementation had ended (especially among math scores). This effect seems driven by in-class student efforts and motivation as well as out-of-class practice in writing and numeracy skills through text-messaging and phone-calling, and the effect is stronger when teachers are more educated. Overall, this impact analysis reveals the additional benefits on educational outcomes and beyond when adult education programs include a training module on the usage of simple communications technologies such as a mobile phone.

This strong impact of basic ICTs on educational outcomes in low-literacy and rural environments contrasts with less conclusive evidence on more sophisticated usage of mobile devices in similar contexts. For example, in an experiment conducted in Burkina Faso, Maredia et al (2018) study the impact of an agricultural extension program wherein animated instructional videos were shown to farmers via smartphone. This intervention consisted of disseminating information on cowpea drying and storing technologies in 48 villages using two separate randomly assigned learning technologies: traditional training consisting of live demonstrations of the technology on the one hand, and instructional video materials shown on an extension's agent mobile phone on the other hand. Compared to the traditional training, instructional videos have the advantages of having almost zero replication cost, of being easily translatable into different languages through voice overlay, and of being easily adaptable to different contexts. Video-based training can also have strong network externalities if the farmer copies the video and sends it to others in their social network. Therefore, this training technology has characteristics that give it a strong potential for scalability in low literacy and remote areas.

Results of their experiment support that, when farmers had already been exposed to the technology, video-based training was as effective as live demonstration in reinforcing farmers' familiarization with and knowledge of the technology. However, when farmers had a low level of exposure to the technology, video-based learning was found to be less effective than live demonstration in disseminating the technology among farmers. Interestingly, despite this mixed evidence, the authors find that two months after the training, 75 farmers had copied the video, shown it to 566 additional farmers, and sent it on to 238 other mobile phones. Therefore, this experiment tends to support that video-based learning can be

a useful complement to traditional live demonstrations by reinforcing farmer knowledge about the technology, and by possibly inducing network externalities in rural areas where agricultural technology knowledge diffusion among farmers is hindered by high transaction costs.

3.2.4. Main lessons

Studies reviewed in this subsection emphasize the positive effect of ICTs on learning outcomes, when intervention designs consider them as monitoring technologies which, combined with appropriate financial incentives, promote teaching performance and school administration efficiency. They also have demonstrated their effectiveness in e-learning adult education programs, more particularly when digital technologies are used as out-of-school learning-by-doing engines, whose basic communication functions (writing messages, making phone calls, making money transfers) can improve learners' numeracy and literacy skills.

However, they stress the limited or mixed impact of e-learning initiatives for children based on sophisticated technologies such as computers or tablets. This mixed impact is probably due to their low uptake in the population, especially due to high relative costs and low levels of familiarization with technologies among intended beneficiaries. In fact, these platforms are more expensive, more vulnerable to climatic conditions, and more prone to theft than more simple devices, without demonstrating additional benefits to in-class teaching. The resulting low penetration of these technologies in SSA populations therefore represents a critical constraint for the scaling up of such initiatives, and they have not proven their effectiveness compared to traditional in-class teaching. Digital technologies should therefore be considered as complementary tools to traditional teaching, so that classes could usefully incorporate training modules on simple and affordable digital technologies use to improve child literacy and numeracy skills.

In a nutshell # 2: learning and monitoring technologies for adult education programs

Technologies

Newspapers, computer, mobile phone, smart phone

Usage

Monitoring of school administration and teaching quality
Out-of-school practice for improving literacy and numeracy skills
Access to knowledge

Stakeholders

School administration, teachers, low-skilled adult populations

Mechanisms

Informational asymmetries on teaching quality and school administration lowered through teacher verification and travel costs reduction
Reduction of teaching materials replication costs
Information search cost reduction (on agricultural techniques or market conditions)

Impacts

Mixed impact and high cost of e-learning through sophisticated digital technologies in developing countries (smartphone, tablets, computers)
Improved numeracy and literacy skills through mobile phone use
School stakeholders' access to information on school funding improves funds management, school enrollment, and pupil performance
Increased teacher attendance and competencies through mobile-based monitoring. Financial incentives may increase e-monitoring impact on teacher attendance
Increased student commitment to the learning program and lower school dropout rates
No clear evidence of higher educational returns through improved access to information

Factors of success/failure

Penetration of the technology (mobile phone, market information system)
Cost of the technology
Information quality (single, multiple-sourced information)
Farmer sociodemographic characteristics

Box 3. iMlango, digital education services for rural and semi-urban Kenyan schools

Intervention

Among the few ICT-based programs targeting African rural areas, the iMlango was a large-scale comprehensive educational program implemented in Kenya from 2015 to 2016, aimed at improving children's learning outcomes in rural or semi-urban areas. **This program offered multipurpose digital education services to 180,000 children, 70,000 of whom were girls, at 240 schools in Kajiado, Kilifi, Makueni and Uasin Gishu counties**. These services included:

- High-speed internet access delivered to program schools through satellite broadband;
- A smartcard-based digital attendance system, monitoring class and school attendance of children and teachers, with semi-conditional payments to incentivize families to ensure their daughters attend school;
- An e-learning platform consisting individualized simulated math tutoring, digital learning content for math literacy, and life skills content;
- Training for teachers for using ICT best practices and integrating technology into the classroom;
- In-person teams in the field to provide maintenance services and support to schools, teachers, and administrators;
- Project monitoring and measurement in real time.

Schools included in the program were identified by poverty rates, attendance levels, and gender policy. The intervention involved: 1) training and supporting teachers in lesson plan formation and delivery using ICT; 2) training of school administrators to support improved lesson delivery to students through ICT channels; 3) policy advocacy and support for development of local, regional, and national ICT-based learning policies in Kenya; and 4) working with community members, parents, and other stakeholders to increase provision of learning materials and ICT-supported learning systems.

Impacts

To assess project impact, a randomized control trial (RCT) was conducted with 260 participating schools. The iMlango Endline Evaluation Report explains that positive impacts were observed at the output level, which were mostly related to teachers' ability to use technology, students' feelings of self-esteem and life skills improvement, and improved engagement in ICTs by marginalized girls. However, expected outcome level impacts did not materialize, due in part to high attrition across the intervention groups which created sample size limitations and made it impossible to detect these improvements. The authors also state that the randomization process may have led to county-level bias.

One important finding of the project consisted of quantifying true attendance rates at iMlango schools, with average attendance found to be 80%. Qualitative interviews of both girls and parents at endline revealed that **digital learning tools had improved their literacy and numeracy levels, including their digital skills**. Additionally, 67.5% of teachers interviewed at endline reported that the iMlango program made their female students more interested in attending school, while 60.5% of female students themselves reported they were more interested in attending, with 67.8% reporting being more excited about school. Unfortunately, there is no concrete evidence that this translated into actual improved attendance rates.

Among the girls whose attendance actually increased, those from disadvantaged households which received the semi-conditional transfers were demonstrating attendance rates 10% higher. However, 31.6% of the girls experienced no improvements in attendance or had worsening attendance. Additionally, 56% of all stipend recipients showed improved attendance rates, while 100% of the worst-attending pupils (attendance <60%) showed improvement upon receiving the stipend. This reveals that removal of financial barriers can have significant positive impacts on school attendance.

When asked about project sustainability, **83.3% of school administrators stated their willingness to raise money to continue running the program in their schools after endline**, although the majority of administrators expressed that project implementation was too short after learning it would only be two years in duration.

Recommendations

The endline study authors recommend that future projects be longer in duration, since it takes significant time to engender long-lasting changes in beliefs and attitudes among educational professionals, students, and households (Advantech Consulting, 2017). They also recommended that exit and sustainability strategies be developed with project stakeholders and beneficiaries from the outset of the project, which would help school administrators be better equipped to take on program funding and operations management upon conclusion of the project. Other recommendations include developing more targeted learning content on life skills and self-esteem for child clubs in order to better attain impacts in these areas, changing the structure of the impact evaluation to ensure sufficient sample sizes for detecting changes in key impact measures, and maximizing the amount of time spent on digital learning tasks per pupil given the large number of pupils relative to available ICT devices.

Sources

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Advantech Consulting. Project iMlango Endline Evaluation Report. (2017). Accessed 12 June 2020.

Box 4. BBC Janala – A cross-media English language learning program in Bangladesh

Intervention

For many residents of developing countries, learning a language widely used in business on an international scale such as English can unblock economic and livelihood opportunities and is often critical for career advancement. However, lack of access to affordable, high-quality language learning programs in many communities can hinder efforts to develop proficiency. To address these issues, the BBC delivered a **cross-media English language-learning service called *Janala*** ("window" in Banlga) **to millions of Bangladeshi citizens from 2005-2014**, with wide-reaching impacts.

BBC *Janala*, funded by the United Kingdom Department for International Development, was **the largest cross-media English teaching platform in the developing world, using a plethora of media to engage with learners, including mobile phones, television, a web-based platform, print materials, English clubs, and outreach content**. For the mobile platform, BBC Media in Action secured significantly reduced tariffs from all six mobile operators in Bangladesh, enabling learners to access mobile-based English lessons for 0.005 USD per minute. The website platform contained both interactive and downloadable lessons and educational materials. These lessons were also available four times per week in the leading Bangla language daily newspaper in the country, Prothom Alo, and lessons were also available for purchase in two books and four audio CDs. Television programming included a weekly drama called *Bishaash* (Believe), which was followed after 24 episodes by an interactive game show called BBC *Janala Mojay Mojay Shekha* (Learning with Fun). In the later phases of the project, a multi-media course called *Amar Engreji* (My English Courses) were developed and made available to learners, enabling them to choose the media platform of their preference to access educational content.

The final phase of the project also included a three-week training workshop series delivered for media practitioners and professionals learning English, with a goal of strengthening the English-language media sector in the country. BBC Media in Action also worked with Bangladeshi NGOs to launch 1,000 peer-led English clubs. Also, during the summer of 2013, a reality TV series consisting of beginning-level learners completing English language-related tasks was also aired, enabling beginners to learn new phrases while also gaining the courage necessary to continue progressing with their own language learning journeys.

Impacts

A case study conducted by Mobile for Development Impact in 2014 found that the BBC *Janala* program resulted in ten million highly engaged users across all media platforms, which was a 50% increase in relation to the number of users in 2011. Fifty-six percent of these users showed increases in proficiency, while 42% demonstrated improved confidence and 48% reported a higher motivation to learn English than they had 10 years previously. Additionally, 28 million Bangladeshis had used the program's services on at least one platform, with 80% of these users in rural communities and 80% from the lowest two socioeconomic groups. Forty-four million people overall were aware of the program at the program's conclusion in 2014. This translates to 1/3 of Bangladeshi adults having engaged with the program in some way.

A case study conducted by McNally on the BBC *Janala* program reports a significant positive correlation between English language proficiency and income for those reached by the program, with an expected 20-25% increase in income for program users who attain an intermediate level as compared to someone with no English proficiency (McNally, 2014). The case study authors note that while measures of engagement with the program and self-reported confidence levels are important, it is even more important to objectively determine how English proficiency has improved in a concrete way among program users (McNally, 2014). However, this is difficult in that English proficiency tests for adults are not often conducted outside of a classroom setting. Other challenges include maintaining a flexible implementation strategy in the face of high volatility and political instability as observed in Bangladesh during the program's implementation and building a mechanism for long-term financial and program sustainability. To accomplish this last goal, it was BBC *Janala*'s wish that the program be taken over and operated commercially upon conclusion of the UK government-funded program in 2014.

Sources

BBC Media Action. Millions of Bangladeshis learn English with BBC Janala. Accessed 12 June 2020. Available : https://www.bbc.co.uk/mediaaction/where-we-work/asia/bangladesh/bbc-janala

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Box 5. IFADEM – A Francophone initiative for open-distance teacher training

Background

The Francophone initiative for open-distance teacher training (*Initiative francophone pour la formation à distance des maîtres* – IFADEM) is supported by the Francophone University Agency (*Agence Universitaire de la Francophonie* – AUF) and the International Organization of La Francophonie (*Organisation internationale de la francophonie* – OIF) with a goal of achieving the 2nd Millennium Development Goal of universal completion of primary schooling worldwide. **IFADEM aims to reinforce professional competency of teachers with little to no initial training, improve teaching methods for French language classes and French instruction through favoring innovative practices and new learning tools, and support national actors involved in developing national continuing education strategies for primary school teachers.** In this respect, IFADEM is a teacher training program focused on strengthening national-level capacities for teaching support and development of appropriate infrastructure.

IFADEM works in conjunction with national Ministries of Education of each implementing country partner, offering both in-person meetings as well as distance-learning trainings for teachers who are not able to leave their classes. The initiative introduces teachers to using Information and Communication Technologies for Education (ICTE) in their classrooms. The initiative has already targeted over 400,000 primary school teachers in rural or semi-urban schools in fourteen different developing countries, most of which are in Sub-Saharan Africa. The program typically begins in each country with an average of 500 teachers in one or two regions of the country. If the first phase is successful, a second phase may then be rolled out with support from technical and financial partners to cover a greater number of teachers and communities.

Training Program Details

The training program is designed to be 200 to 300 hours in length and can generally be completed in nine months. Teachers complete distance-learning trainings at their own pace and in parallel with in-class activities, but there are also two or three general group meetings that occur over a two-to-three-day period during the school vacation. The content for the training programs is produced locally and tailored to specific cultural and linguistic contexts. The remote independent trainings alone being insufficient for ensuring long-term improvements in target objectives, the training program is paired with small group meetings and individual in-person tutoring delivered to teachers by inspectors, school administrators and teaching counselors. Each teacher receives training supporting materials, a dictionary and a grammar book, both audio and physical teaching supporting materials, and basic training in Internet and computer literacy as part of the program.

Technology

In terms of technology, IFADEM uses multiple methods of content delivery. For example, **a distance learning platform with contextually adapted learning activities called Moodle is used to deliver digital brochures to project beneficiaries. These resources can be accessed online or downloaded from the Digital Spaces installed in teacher training institutes.** Internet, video-conferencing and collaborative platforms are used for teacher training and to organize work between local program developers and teams of francophone university experts. In addition, IFADEM has also expanded into individualized delivery of content, such as audio training by cellphone for educational professionals and teachers in Madagascar. **A mobile platform is available for teachers to correspond with each other and their tutors, submitting questions and receiving responses by voice or SMS.** Although IFADEM does not employ a strategy of "training by phone," mobile phones do allow teachers to access pre-recorded audio teaching supports, listen to the radio, and access banking services in addition to communicating with tutors. The Digital Spaces mentioned above each contain 20 to 30 computers with open-access software, an audiovisual unit, television, and DVD player, and other materials such as printers, copiers, scanners, and video projectors. The Digital Spaces are serviced by locally produced energy such as solar panels coupled with batteries.

Preliminary Impacts

An evaluation of the experimental phase of the project conducted in 2010 by the ATEMA Cabinet of OIF found that 1,184 teachers and 50 local actors were reached by this phase of the program. The level of success was also very high, with **96% of teachers in Burundi and 95% of teachers in Benin completing the program and successfully obtaining certification**. The experimental phase evaluation did note that there was a problem with mp3 files that made them unusable, and that several of the Digital Spaces seemed to be underutilized. However, the overall positive results of the pilot phase justified the scaling up of the program and rollout to other countries and regions. As mentioned above, **over 400,000 primary school teachers have been reached since the program's initiation.** Plans for full program evaluation in Burkina Faso, Comoros, Mali, and Chad are currently underway.

Source

IFADEM. (2020). Accessed 12 June 2020. Available: https://www.ifadem.org/

3.3. Information technologies and health outcomes

The use of ICTs, such as mobile phones or more sophisticated mobile digital technologies, to improve healthcare practices has the potential to change public health intervention design in SSA. In a context of missing health and transport infrastructures, poor health information systems, under-trained health staff, and a predominantly rural and poorly educated population, ICTs – especially mobile phones – can assure various healthcare-related functions. These technologies can assist with collection and dissemination of information regarding health behaviors, providing healthcare follow-up reminders, or assisting health workers in their everyday work life at relatively low cost (Head et al, 2013; Aranda-Jan et al, 2014; Agarwal et al, 2015; Aker, 2017; Hampshire et al, 2017). Moreover, one particularity of the mobile phone technology is its omnipresence in everyone's life, even the poorest, which make such devices a privileged tool for delivering health information or healthcare services (Head et al, 2013). For these reasons, mobile-based health public services (mHealth)[18], especially those relying on simple mobile phone devices, are expected to promote cost-effective and efficient health policies (Aranda-Jan et al, 2014; Hampshire et al, 2017).

In a review of 44 African mHealth projects conducted between 2006 and 2013, Aranda-Jan et al (2014) provide a general picture of mHealth projects in Africa. They identify six levels of mHealth interventions:

1. Patient monitoring (follow-up and medication adherence)
2. Health worker capacity building
3. Health worker monitoring
4. Drug supply chain and stock management
5. Patient sensitization and education
6. Data collection and reporting

They also identify four principal areas of intervention: HIV, malaria, tuberculosis and antenatal care. Most projects are implemented locally, with no scaling-up, which precludes evidence presented in this subsection from excessive generalization. We provide below a non-exhaustive evidence-based review of selected mHealth interventions in SSA.

3.3.1. MHealth for vulnerable groups in West Africa

Healthcare reminders through phone calls and text-messages is a relatively new but widespread mHealth service in developing countries (Head et al, 2013), including SSA countries. In fact, when health infrastructure capacity and coverage are low and the travel and opportunity costs associated with medical appointments are high, using mobile phones to inform and communicate with patients could help overcome the infrastructure gap and relieve health worker workload, especially in rural areas. Mobile phones can indeed be very effective in informing the population on health behaviors fostering disease prevention and containment. This potential is examined in three studies, conducted in rural Ghana, Burkina Faso, and Kenya, analyzing the contribution of mHealth to maternal and child healthcare and immunization.

First, Laar et al (2019) assess the attractiveness of a mHealth program delivered to women of childbearing age in three districts of the Upper West Region, one of the poorest regions in Ghana. This program, named Technology for Maternal and Child Health (T4MCH), was an interactive platform enabling health workers to send maternal and child health-related information to Ghanaian lactating or

[18] Betjeman et al (2013) define mHealth as follows: "Mobile health, or mHealth, is the utilization of short messaging service (SMS), wireless data transmission, voice calling, and smartphone applications to transmit health-related information or direct care."

pregnant mothers through mobile phone (via text messages, voice messages, or phone calls). The study consisted of collecting survey data from randomly administered questionnaires to 489 lactating or pregnant mothers, among whom less than one-third were informed about the mHealth intervention. Among the questionnaire respondents, 10.2% received follow-up mobile reminders on medical appointments, health behaviors, and care before and after delivery, as well as other child and maternal health-related topics. The authors found that the acceptability of the program was very high among women and health workers. However, at the time of the study, qualitative information retrieved from interviews stressed that access to the mobile network, electricity access, and mobile phone ownership were the three major challenges preventing this program from reaching its intended beneficiaries. Lack of mobile phone training in addition to reading and numeracy skills were also identified as being important obstacles to the program's outreach. Despite these limitations, this study highlights the potential of delivering health information through mobile-based technology to populations in need of specific care and living in a rural setting.

Second, Yé et al (2018) have studied in more detail the implementation in 2013 of a similar mobile-based information system (MOS@N) providing health information to a vulnerable group – women, children and people living with HIV/AIDS – in Nouna, a rural area of Burkina Faso. The aim of this intervention was to reduce the high maternal and child mortality rates and the high prevalence of HIV/AIDS in the country through improved follow-up of people living with HIV/AIDS (hereafter PLWHA). It consisted in equipping health workers (godmothers charged with pre and postnatal care and HIV/AID facilitators) with mobile phones and allowing them to inform and provide care to PLWHA through the MOS@N system. This system is an interactive voice-response and SMS-transmission system delivering automated health information in French and four additional languages spoken in Burkina Faso to health workers for patient use. Categories of information delivered include awareness raising and sensitization messages, appointment or return visit reminders, and a communication platform enabling phone calls between health centers and health workers. All of this information, including confidential information regarding PLWHAs registered in health centers, was centralized and stored in a database.

To assess the impact of this mHealth intervention, Yé et al (2018) combined sociodemographic data from Nouna Health District with survey data collected in 17 of the 25 health centers located in the region, among which 5 were selected to receive the intervention, and qualitative survey data gathered from interviews with some 52 godmothers and 15 health workers. The obstacles to the mHealth intervention's implementation and outreach were quite similar to those highlighted by Laar et al (2019). In fact, Yé et al (2018) point out the lack of connectivity and the insufficient training of health workers in mobile phone technology, the majority of whom were using mobile phones for the first time and lacked basic reading and writing skills. Moreover, the authors mentioned the vulnerability of mobile phone devices to the rural and arid intervention context (more than 65% of mobile phone devices were damaged during the intervention). Despite these challenges, the intervention was perceived positively by survey participants, with a large majority agreeing that mobile phones help transmit health information and exchange with patients. Thirty months after the intervention, the number of PLWHAs registered in health centers increased from 301 in 2013 to 1008, while the follow-up turnout rate was reduced from 10% to less than 1.6%. Over the same period and compared to control health centers, the number of prenatal care consultations increased by 9.5%, the number of tetanus vaccines given to pregnant women increased by 43%, and the number of polio and BCG vaccines by 11%. Therefore, the dissemination of mobile technology with the aim of improving healthcare information transmission between health centers, health workers, and vulnerable populations such as PLWHAs in resource-limited environments has demonstrated its effectiveness in improving prenatal care and immunization.

Third, within a project of antiretroviral therapy provision implemented in three clinics in Kenya between 2007 and 2008, Lester et al (2010) assess a similar mHealth intervention (WelTel Kenya1), consisting of sending HIV-infected patients SMS reminders for antiretroviral medication. Among 538 eligible participants[19], 273 were randomly assigned the mHealth intervention while the remaining ones formed a control group under standard anti-retroviral therapy. Each week on Monday, patients were sent a message by health workers enquiring about their health condition, followed by a phone call if the patient sent negative feedback or remained silent. The communication established through mobile phones between patients and health workers was aimed at monitoring and informing the former about their antiretroviral medication. The authors found that patients who had benefitted from the mHealth intervention demonstrated a greater adherence to the antiretroviral therapy and higher rates of viral suppression compared to control groups. Therefore, this additional experiment supports the effectiveness of mobile phones for collecting information about patients' status and informing them about their medication.

The question of delivering healthcare information in resource-limited settings in West Africa through text messaging has been addressed recently in other studies and contexts such as Zurovac et al (2011), Rokicki et al (2016), and Omole et al (2016). These studies generally point to the health benefits of such interventions and the positive perception or adherence of their beneficiaries.

3.3.2. MHealth for frontline health worker decision support

In a context of high fertility rates, high maternal mortality rates, and skilled human resources shortages in primary health centers in Nigeria, McNabb et al (2015) evaluate the impact of the m4Change mobile application, built on the CommCare platform[20] (see Box 6), on prenatal care provision by community health extension workers (CHEWs) and community health workers (CHWs). While existing reviews of such applications in developing countries stress their positive impact on healthcare and high adherence among frontline health workers (Agarwal et al, 2015), evidence from West Africa, especially Nigeria, on maternal and child healthcare is scanter. Through the m4Change application, CHEWs and CHWs have automatic access to patient demographic and medical records (demographic information, age, height/weight, blood pressure, immunization status, laboratory diagnoses, ongoing treatments, etc.), and can receive support for healthcare decision making from the CommCare platform. Based on patient data, platform data, and web data processing, the application can provide recommendations for maternal nutrition, specific treatments, diagnoses, or patient follow-up. Recommendations are available in Pidgin, English, or Hausa.

The intervention under study, launched by the end of 2012, consisted of providing 152 health workers (CHEWs/CHWs) and 20 supervisors in 10 primary health centers located in Abuja and Nasarawa provinces with mobile devices (either simple mobile phones or tablets, depending on patient density), and with training on how to use the m4Change application. The authors assessed the impact of the intervention on the quality of antenatal care services, based on survey information gathered from 267 adult patients before and after the intervention. Antenatal care quality was measured using a 0-25 scale

[19] Eligibility for treatment depended on patient access to mobile telephony (through her own ownership or a tier's ownership) and literacy (illiterate patients were eligible if they knew a literate individual who could assist them)

[20] CommCare is an open source platform supporting more than 2,000 health projects in some 80 countries. This type of open source platform enables users to develop their own applications based on various functions – data collection and reporting, training and decision support, emergency referrals, work planning, and supervision of and communication with health workers – and to adapt it to their health intervention designs and objectives (Agarwal et al, 2015; CommCare, 2019). CommCare applications work on low-end feature mobile phones and can therefore be scaled up easily. As an illustration, a CommCare application has been scaled up in India, supporting 360,000 health workers in their case management and in health decision making.

global composite index, aggregating quality scores related to 25 antenatal care criteria: 12 related to technical antenatal care services and 13 related to antenatal care counseling. The authors found that the average global quality score increased from 13.33/25 before the intervention to 17.77/25 one year after the intervention. This positive effect was mostly explained by a significant improvement in 11 out of 12 patient education and health worker counseling criteria (with the counseling score increasing from 5.45 to 8.67). Regarding technical care, a noticeable increase in the index was driven by greater HIV test provision and blood pressure measurements. Overall, information on patient satisfaction before and after the intervention demonstrates a higher adherence to antenatal care services after the mHealth intervention.

This evidence is line with the study of Agarwal et al (2015), who undertook a meta-analysis of 42 evidence-based mHealth studies to assess three dimensions of mHealth interventions: the feasibility of mHealth for health workers (14), the training of health workers in mHealth use, and the effectiveness of mHealth-based healthcare provision by health workers. First, regarding the feasibility of mHealth interventions, all studies focusing on this issue support that health workers were able to use mHealth applications. Some of them even highlighted that mobile health applications increased their motivation, empowerment, and credibility in their communities. Second, the authors found that mHealth applications have been shown to be effective in improving patient health outcomes by enhancing the following areas of intervention: patient data collection and reporting, health worker decision making and training, patient emergency referrals, coordination of health system actors, patient follow-up, and health worker work-planning through alerts and reminders. Third, the authors' review also suggests that training in mHealth use is an important component of mHealth interventions and a condition for their effectiveness and for the quality of data collection. They notably emphasized that the duration of trainings may differ according to the intervention's complexity and scope as well as the health worker's skill level, and that the scope of trainings ranges from introduction to mobile phone functionality to instruction on mobile phone usage and additional software applications.

3.3.3. Main lessons

In their SWOT analysis of 44 African mHealth projects, Aranda-Jan et al (2014) highlight the significant potential of mHealth projects to support health systems in Africa.[21] Overall, African mHealth projects under study benefitted from a high adherence among patients, health workers, and staff. The authors identified the following recurring positive outcomes of these projects: improved patient access to basic health services such as medical appointments, reduced delays in communication between patients and health staff, improved data collection and reporting, reduced patient travel costs, improved health worker compliance to treatment guidelines, and improved patient sensitization and medication. Among other things, the authors point out that health staff training on mobile technology use, monitoring and evaluation, and setting adequate incentives are central for the success of mHealth project management. They also stress the importance of integrating such projects into the healthcare system, into the local context (or instance, by making the mHealth application available in local languages), and of promoting partnerships with public or private entities such as NGOs, universities, research institutes, and hospitals.

However, Aranda-Jan et al (2014) highlight that evidence from RCTs are less conclusive than results from pilot project analyses, and RCT results call scalability and reproducibility of pilot projects in other contexts into question. Interestingly, a recent study conducted by Hampshire et al (2017) in Ghana and Malawi introduces a more nuanced perspective, in contrast to the solidly optimistic view of many mHealth initiative evaluations. Studying the informal mobile phone practices of health workers in these

[21] At the same time, the authors question several aspects of impact analysis design, including small sample size, possible omitted confounding factors, lack of external validity, small scale of projects, and data quality.

countries, they highlight the moral and political economy costs incurred by low-level frontline health workers. They conducted interviews with low-paid health workers in entry-level positions and found that it was a common practice to informally use mobile phones to deliver extra healthcare services, especially to poor households and hard-to-reach rural communities. Such practices reflect a shift in the workload and tasks borne by low-level health workers, which may in turn reduce health service quality, health worker wellbeing, and the sustainability of mHealth programs. In conclusion, the authors warn about the potential unforeseen effects of mHealth initiatives, stressing that "although the literature on formal mHealth emphasizes cost saving, informal mHealth may be more about cost shifting" (p.40).

In a nutshell # 3: mHealth and health service delivery

Technology

Mobile phones, smartphones

Usage

Health reminders, sensitization messages, communication platforms, information collection

Stakeholders

Health centers, health workers, citizens, especially vulnerable people (pregnant women, mothers and young children, HIV patients)

Mechanisms

Disease prevention and containment through reduced information search and communication costs between health centers, health workers and patients

Patient follow-up through reduced verification and travel costs reduction

Impacts

High adherence to interventions from patients, health workers, and health center staff

Increased patient follow-up (e.g. health center patient registration numbers)

Enhanced health worker decision making and training

Improved prenatal care, immunizations, and other health behaviors (e.g. vaccination rates)

Improved patient follow-up and data collection

Increased coordination between health system actors

Risk of frontline health worker over-solicitation

Factors of success/failure

Penetration of the technology (mobile phones in particular)

Risk of health worker over-solicitation

Partnerships with other private stakeholders (NGOs, universities, research departments/institutes, hospitals)

Local contexts (languages, habits, customs)

Box 6. CommCare for mHealth applications in SSA and beyond

CommCare: technology Overview

CommCare, developed by the tech social enterprise Dimagi, is an **open-source mobile platform widely used to develop and implement mHealth interventions to support frontline workers in developing countries and other low-resource settings.** In fact, a Johns Hopkins University report from 2016 found that CommCare was the most frequently used platform for mHealth applications in developing countries. CommCare clients can use the platform to meet a diverse set of needs, including data collection, healthcare service delivery, supporting clients, managing facilities, facilitating transactions. The CommCare Mobile component is primarily used by frontline community health workers for data collection and service delivery, through use of a phone or a tablet in the field. The CommCare HQ component is used for application management and reporting and is usually accessed through a laptop or desktop computer. Through the CommCare HQ website, supervisors, researchers, project managers, or data analysts can design mobile applications, access stored data collected through the CommCare Mobile platform, and manage users.

CommCare is used for a diverse set of applications in mHealth and other areas, including data collection, decision support, as a job aid, a counseling tool, and for improved supervision through monitoring of worker activity data. **CommCare projects supported by governments and NGOs have helped bring mHealth applications such as registration forms, decision support tools, and multimedia resources to frontline health workers in 80 countries providing healthcare to hundreds of millions of people, often in remote, underserved regions.**

Impacts

As of 2019, at least **61 peer-reviewed studies** have been conducted on CommCare and its effects on healthcare systems in low- and middle-income countries, collectively showing that **CommCare improves Frontline Worker (FLW) performance, client behaviors, and client outcomes**. Among these studies, several randomized control trials are worthy of note. For example, an RCT conducted in Tanzania found that mothers tracked by FLWs using CommCare had significantly higher facility-based delivery rates (74% in intervention villages versus 63% in control villages), and that this effect was especially pronounced for first-time mothers with low rates of antenatal care use (32% higher facility delivery rates than control villages). Another RCT, conducted by Mathematica Policy Research, evaluated the effect of CommCare on a CARE International health services project in Bihar, India that included client mapping, home visits, family and reproductive counseling, and delivery of health messaging via interactive voice messages clients. The only difference in the control and treatment groups was that FLWs in the treatment group were provided with a CommCare application that consisted of a scheduler supported by MOTECH[22] (another mHealth platform). The study results showed significant positive impacts of the CommCare application on FLW interactions such as antenatal care, delivery and newborn care, child nutrition, and reproductive health. There were also statistically significant improvements in health outcomes in these same areas, including a 73% increase in women attending at least three antenatal care visits as compared to the control.

Overall results of literature on CommCare usage in frontline settings has been positive. The plethora of studies evaluating CommCare interventions, including several RCTs, have shown that mHealth platforms such as CommCare have the power to overcome barriers to healthcare access in low-income settings and remote regions of Sub-Saharan Africa and Asia, improving delivery of health messaging, FLW interaction with patients, FLW performance, patient health outcomes, quality of care, and overall efficiency of healthcare program management.

Challenges

Despite the overwhelmingly positive evidence that CommCare has improved health services delivery and healthcare outcomes in a variety of low- and middle-income settings, there are also some key challenges that need to be addressed. For example, some studies cited broken phones and devices that remained unrepaired, difficulties finding a source of electricity to charge devices, and low internet connectivity that hampered efficient sharing and synchronization of data among FLW teams. Other studies noted that organizations scaling up CommCare interventions may have limited IT capacity to satisfactorily maintain technology. Another challenge in some cases has been low take-up or usage of CommCare applications among FLWs, or decreasing usage over time, which has been referred to as the "novelty" effect of technology. Above all, it is important for programs to provide sufficient training to FLWs, since they are ultimately the ones delivering healthcare services, interacting with patients, and using the CommCare applications in their everyday work. Moreover, significant training time was required in order for FLWs to see the real-world value the CommCare application would provide them in their work.

Source

CommCare, The CommCare Evidence Base for Frontline Workers: Overview, CommCare Report, August 2019.

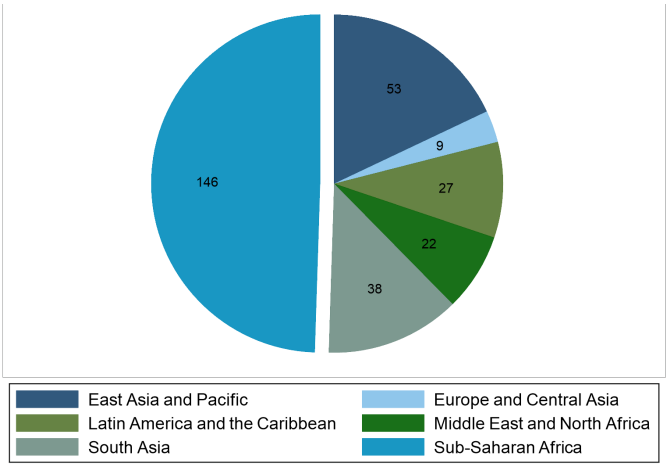
[22] Available at https://motechproject.org/

3.4. Mobile money and poverty reduction

Mobile Money (MM) is a digital application that relies on the mobile phone network to deliver basic financial services – money deposits, money transfers, and withdrawals – without requiring bank account ownership. MM runs on simple mobile phone devices, which explains why its adoption has been rapid and expansive throughout Sub-Saharan Africa, where the telecommunications, transportation, and financial infrastructures are often lacking and transaction costs are high (Mothobi & Grzybowki, 2017; Aker, 2017; Suri, 2017; Aron, 2018).

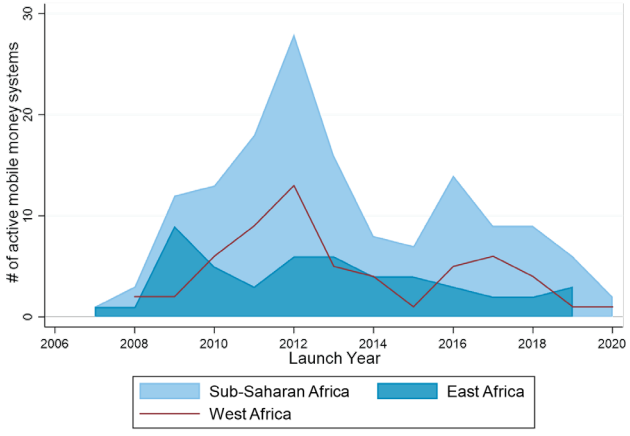
By the end of 2018, 45.6% of registered MM customers were located in SSA, with 33.2% in South Asia and 11% in East Asia and the Pacific. SSA also contains almost half of the MM systems implemented worldwide (Figure 19). The penetration of this technology in the region has reached high levels: while 60% of the adult population has an MM account (almost 100% in Kenya), one-third of the same population was an active user in 13 SSA countries (GSMA, 2018).[23] The pace of MM adoption in SSA has been slowing in recent years (Figure 20). However, there is still significant potential for Nigeria and Ethiopia, the so-called "MM sleeping giants", where financial inclusion and the penetration of MM services is below the regional average (GSMA, 2018).

FIGURE 19. NUMBER OF MOBILE MONEY SYSTEMS IN SSA AND THE REST OF THE WORLD.



Source: Mobile Money Tracker, GSMA, 2019c. Note: 294 MM systems.

FIGURE 20. NUMBER OF MOBILE MONEY SYSTEMS IN SUB-SAHARAN, WEST, AND EAST AFRICA.



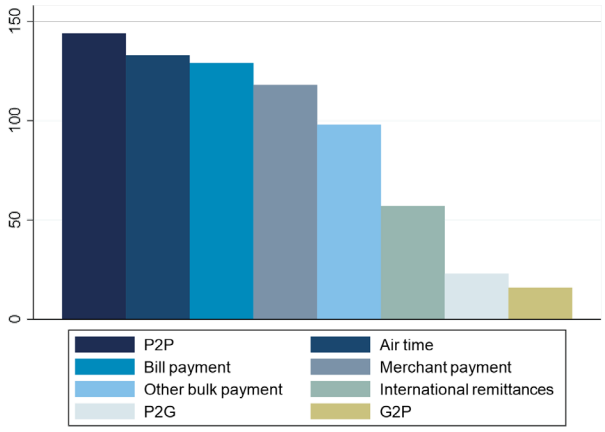
Source: Mobile Money Tracker, GSMA, 2019c.

[23] Among these 13 countries, 4 were West African countries: Benin, Burkina Faso, Côte d'Ivoire, and Ghana.

In addition to money storage and person-to-person (P2P) payment services, MM systems can also propose person-to-business (P2B) transactions such as sales payments, person-to-government (P2G) transactions such as bills or tax payments, business-to-person (P2B) transactions such as wage payments, or government-to-person (G2P) transactions such as vouchers or cash transfers (Suri, 2017; Aron, 2018). Figure 21 below shows that among the 145 MM systems deployed in SSA, P2P transaction services, airtime, and bill payments are the most common features used across these systems. MM money is therefore an effective vehicle for multipurpose financial transactions with a proven effect on financial inclusion. In fact, MM has been found to improve risk-sharing (Jack & Suri, 2014) and access to savings or credit (Aker & Wilson, 2013; Bharadwaj et al, 2019), to accelerate poverty alleviation through private remittances (Kikulwe et al, 2014; Munyegera & Matsumoto, 2016), public transfers such as cash transfers (Aker et al, 2016b), subsidized education fees (Adida et al, 2018), or wage payments (Blumenstock et al, 2015).

In this subsection, we review evidence on MM-based initiatives in SSA. We first focus on M-Pesa, the first MM system that has had a strong impact of public service provision, in particular access to financial services, in Kenya. We also address evidence on various applications of this technology, from public cash transfers to school-fee or salary payments.

FIGURE 21. MM SYSTEM DEPLOYMENT IN SSA, BY SERVICE PROVIDED.



Source: Mobile Money Tracker, GSMA, 2019c.

3.4.1. The M-Pesa revolution and the unbanked in Kenya[24]

The rapid emergence and diffusion of MM in SSA occurred in a context of high transaction costs and strong market failures in public service provision (Suri, 2017; Aker, 2017; Aron, 2018). The high transportation and information costs related to missing telecommunications and transportation infrastructures, informational asymmetries on financial markets that exclude the poorest from accessing formal financial services, incomplete insurance markets that preclude households from properly insuring against idiosyncratic and covariant shocks, and the high opportunity costs of holding cash for repeated small transactions and long-term travel, are combined factors that encourage MM diffusion in SSA. Given this context, MM could bring greater welfare to the poor by improving access to financial services in the subcontinent.

MM's most successful experience remains the M-Pesa system, launched in Kenya in 2007. Subsequent MM systems have generally followed the functioning principle of M-Pesa: consumers first have to create

[24] The stakes of digital financial technologies development for financial inclusion in West Africa are addressed in the second companion background paper "The State of Digital Financial Services in Francophone West Africa".

an MM account with an MM agent, providing a proof of identity document, and then to deposit money into their account. Once this step is complete, MM users can make PIN-secured transfers to any mobile phone owner in the country, receive money transfers from other MM users in the country (individuals, businesses, or government agencies), and withdraw money in the presence of MM agents. Each transaction, with the exception of deposits, can incur transaction fees, in a similar way as with a standard bank account. The greatest difference with the traditional banking sector lies in the fact that MM agents buy, hold, and manage a stock of e-money that they can trade against cash money with MM users. The MM agent network is generally composed of neighborhood shops, drugstores, gas stations or street corner kiosks, which facilitate reaching populations located in remote areas, unserved by the traditional banking infrastructure and generally excluded from the commercial banking sector.

In a seminal field research study conducted in Kenya between 2008 and 2010, Jack et al (2013) and Jack and Suri (2014) show that the deployment of M-Pesa, the most ubiquitous Kenyan MM system, has reduced transaction costs for financial transfers and improved M-Pesa users' resilience to shocks through risk-sharing. First, Jack et al (2013) investigate the effect of M-Pesa adoption on the volume and characteristics of interpersonal transactions. They find that M-Pesa adoption is associated with an increased likelihood of transferring or receiving money from a relative, higher frequency and larger size of transactions, greater geographical distance between transaction senders and recipients, and a higher likelihood of reciprocal transactions[25]. The reciprocal nature of many M-Pesa payments (around 22% according to the authors' dataset) suggests that M-Pesa adoption and diffusion enabled the expansion of credit and insurance-like interpersonal transactions, which could have helped households insure themselves against adverse shocks and facilitated consumption smoothing. This issue is further addressed by Jack and Suri (2014), who use the same survey to study the effect of MM on risk-sharing. They exploit the exogenous reduction in financial transaction costs resulting from the fourfold increase in the size of the M-Pesa agent network that occurred between the survey rounds and estimate the impact of M-Pesa usage on per capita consumption smoothing. In particular, they stress that using M-Pesa allows households to mitigate the negative effect of adverse income shocks on consumption, while nonusers experienced a 7% drop in consumption following adverse shocks. They also show that households facing negative shocks receive more frequent and larger transfers, from a larger and more geographically distant network of individuals, if they use M-Pesa.

In conclusion, these studies provide strong evidence that MM transfers, through M-Pesa, represented a very effective risk-sharing mechanism in Kenya, but also suggest that such a platform could be effective in other African countries with similar conditions of high transaction costs and financial market failures (Riley, 2018). Jack et al (2013) and Jack and Suri (2014) also stress that the success of MM depends on the size of the MM agent's network with whom MM users can interact (see also Suri, 2017). Moreover, evidence also stresses that user network size is also a critical determinant of MM adoption (Murendo, 2018), supporting that MM is a network good whose social and private benefits increase with the size of other users' networks (Bjorkegren, 2019).

3.4.2. From mobile money to mobile banking

MM can be considered as a shadow banking system[26] (Suri, 2017) that promotes "semi-formal financial inclusion" (Aron, 2018) by proposing financial products (savings, insurance, payment mechanisms)

[25] Households were asked whether they have been "engaged in any transaction in the last six months that saw a reciprocal (reverse) transaction from the same counterparty" (Jack et al, 2013).

[26] According to Bernanke (2012), "shadow banking, as usually defined, comprises a diverse set of institutions and markets that, collectively, carry out traditional banking functions--but do so outside, or in ways only loosely linked to, the traditional system of regulated depository institutions".

outside the formal banking sector realm to populations that cannot obtain access to accessible, affordable and adapted traditional financial services (Ondiege, 2015).

The recent development of MM-based mobile banking services in East Africa suggests that MM filled in the missing link that was preventing the formalization of financial services to the "unbanked". As underlined by Aron (2018), MM diffusion has increased financial transparency by providing a recorded financial history of every deposit, withdrawal, and transfers or payments made by MM users. It has also reduced the fixed costs of interacting with underbanked households typically incurred by banks, related to the small average loan amounts and remoteness of these populations (Bjorkengren & Grissen, 2018). This greater financial transparency reduced information asymmetries between the formal banking sector and MM users, together with the reduction in fixed banking costs, and spearheaded a range of mobile-based financial innovations supporting the formal financial inclusion of the unbanked.

In 2012, in the wake of M-Pesa countrywide success, the Kenya telecom operator Safaricom has partnered with Commercial Bank of Africa to propose a savings and micro-credit platform, M-Shwari, based on M-Pesa technology. Two years later, M-Pesa was able to be used for international remittances in 90 countries worldwide. More recently, Safaricom also launched a health insurance platform, M-TIBA, enabling M-Pesa users to save and pay for healthcare, and M-KOPA, a pay-as-you-go system for solar-powered lighting and mobile charging intended for rural Kenyans. Other successful experiences of MM deployment and broadening to formal financial micro-products can be found in other African countries such as Côte d'Ivoire (see Box 7). However, it is worth noting that not all MM rollout has been successful in promoting financial inclusion, as evidenced by low rates of MM uptake in Nigeria (See Box 8), because of poorly designed regulatory frameworks, inadequate taxation and pricing, and the small size of the MM users/agents' networks.[27]

Despite the progresses described above, there is as of yet little empirical evidence on formal financial inclusion of the underbanked stemming from MM-based financial service extension initiatives. A recent paper authored by Bharadwaj, Jack & Suri (2019) provides novel and insightful findings on the effectiveness of digital loans through M-Shwari in improving financial inclusion. M-Shwari offers eligible M-Pesa users a savings account and the possibility of contracting small, short-term, uncollateralized digital loans without requiring any banking or credit history. Loans must be repaid within 30 days and incur a 7.5% monthly interest rate, with a loan size ranging from one to 100 US dollars. Eligibility for M-Shwari loans is based on a credit score cutoff determined by the user's mobile phone and M-Pesa data and assigned when the customer opens an M-Shwari account. This credit score determines the user's loan limit, which can increase over time according to the user's savings and loan repayment history.

The authors estimate the impact of M-Shwari loans on user financial inclusion within a regression discontinuity design setup, consisting of comparing financial outcomes of M-Pesa users that are just below versus just above the credit score cutoff, over an 18-month period. These users are expected to be similar in many respects, with the only difference being that those below the cutoff are not eligible for an M-Shwari account, while those above the cutoff are eligible. First, the authors find that being eligible for an M-Shwari account increases user likelihood of contracting a loan, the frequency of taking out loans, and average loan size. To illustrate how M-Shwari expanded access to credit, the authors find that average loan size of those above the cutoff was twice that of individuals below it. They also stress that this observed credit expansion was due solely to M-Shwari and that there has been no substitution with other formal or informal sources of credit. Additionally, the authors find that this system did not

[27] Companion Report #2 "The State of Digital Financial Services in Francophone West Africa", Section 3, further addresses these issues.

lead to an increase in user over-indebtedness through high interest payments. In a second step, the authors investigate whether improved access to credit through M-Shwari increased household resilience to adverse shocks. Their results stress that households with M-Pesa users above the M-Shwari credit cutoff are less likely to report spending cuts in response to adverse shocks. Moreover, M-Shwari appears to help mitigate all types of shocks but was found to be more effective in the context of emergency expenditures induced by health shocks or family losses.

These empirical analyses, pointing out the short-term positive effects of MM and mobile banking on consumption smoothing, need to be complemented by longer term studies on the (gendered) impacts of MM on poverty reduction. This is what Suri and Jack (2016) have done in a study addressing the long-run impacts of M-Pesa deployment in Kenya on *per capita* consumption levels, occupational choice, and poverty headcount. Based on survey rounds conducted between 2008 and 2014 over representative samples of 3,000 households, they estimate a reduced-form function of household outcomes and proxy MM adoption by an exogenous measure of MM access, namely the household's geographical proximity to MM agents. They find that an increase in MM agent rollout led to an increase in per capita consumption and lifted 192,000 households out of poverty. They find that these long-run effects are explained by a more efficient allocation of labor and savings and are stronger for women and households headed by women. Interestingly, they find that M-Pesa rollout increased women's likelihood of working in a business and reduced the likelihood of farm labor. They also stress that MM agent network expansion reduced average household size without impacting migration, suggesting that MM could have empowered women and reduced fertility rates or facilitated sending children to boarding schools.

In a nutshell # 4: mMoney and financial inclusion of the unbanked

Technologies
Mobile money, mobile banking

Usages
Private transfers, money storage, savings, credit

Stakeholders
Farmers, firms, rural households, women, banking sector

Mechanisms
Financial and travel costs reduction
Informational asymmetry reduction between transfer recipients and donors
Informational asymmetry reduction between MM users and the banking sector

Impacts
Consumption smoothing during adverse shocks through precautionary saving and risk-sharing
Increased per capita consumption and reduced prevalence of poverty
Improved access to formal credit and saving services
Improved access to MM-based public services (e.g. mHealth)
Improved allocation of labor and capital
Empowerment of women using MM
Private sector expansion
Suggested increase in child school attendance rates and lower migration in households using MM

Factors of success/failure
Penetration of the technology (mobile phones in particular)
Size of the mobile money agent network
Regulatory, taxation, pricing frameworks

Box 7. Mobile Money rollout and the agricultural sector: insights from Côte d'Ivoire

Rollout of Mobile Money Services

Mobile money (MM) has been shown to increase social welfare in low-resource settings through a number of mechanisms. MM initiatives include MM financial services provided to farmers through partnerships between financial institutions and mobile network operators (MNOs) with bank-to-mobile (B2M) integration, as with the example in Côte d'Ivoire discussed below.

Mobile Money Effects on Income and Agricultural Production: A Conceptual Framework

Access to mobile money services can lead to increased welfare through a number of specific pathways. One such pathway is remittances from family and friends. Traditional methods of sending and receiving remittances, including bank transfers, cash transfer services, and sending physical cash via transportation networks, are subject to high transaction costs, high travel costs, and information asymmetries that result in suboptimal take-up and use of these services. **Mobile money reduces these transaction costs and informational gaps by enabling fast, low-cost, remote transactions through SMS messaging**. Additionally, the broad penetration of MM services in remote rural areas has resulted in reduced travel time and costs for sending and receiving remittances.

Another pathway through which MM can improve welfare is through more intensive use of agricultural inputs. Traditionally, semi-subsistence smallholder farmers in resource-constrained settings are characterized by low market participation due to transaction costs, liquidity constraints, and risk aversion. MM can reduce some of these barriers by decreasing use of informal savings and insurance mechanisms, reducing negative impacts of economic shocks through remittances, and enabling faster, easier access to payments for sales of agricultural produce and wages for agricultural labor. Another related mechanism is through increased commercialization of agricultural produce, as higher rates of input use and productivity facilitated by use of MM services can lead to higher crop yields and marketable surplus.

MM Services with Bank-to-Mobile (B2M) Integration in Côte d'Ivoire

Two notable examples of innovative collaborations between financial institutions and MNOs in Côte d'Ivoire show that **financial services digitization can help smallholder farmers overcome liquidity constraints and achieve higher incomes where market failures have traditionally impeded access to necessary inputs**. The first example involves the Advans Côte d'Ivoire microfinance institution, which partnered with MTN Côte d'Ivoire and a network of cocoa farmers in 2014 to offer farmers a branchless savings account accessed through an MM platform. Farmers choose what portion of their farm income they want to save, and the rest is paid to them in cash. Farmers can access their savings at the end of the crop season by visiting an MTN location after a B2M transfer; they can also transfer money from their MTN mobile accounts to their Advans savings accounts. As of 2017, this initiative has reached 13,500 farmers across 100 cocoa cooperatives. A second example comes from the Société Ivoirienne de Banque (SIB), which partnered with Orange Côte d'Ivoire and three cocoa cooperatives. The cooperatives process payment of premiums to the farmer's SIB bank account, and the farmer can choose to withdraw cash from the SIB account directly or through Orange's mobile money account after a B2M transfer. As of 2017, 48 percent of the 2,400 participating farmers had integrated their SIB accounts with the Orange MM service, and almost 500 farmers were paid their premium. As of 2018, project partners were scaling up the integrated platform to 8,500 cocoa farmers in nine cooperatives and planning to pay 100,000 farmers through direct mobile-money bulk payments by the end of the year.

Another digital intervention, the Olam Farmer Information System (OFIS), is an Android OS application used for collecting farm data on a phone or tablet instead of using a traditional pen-and-paper form. The OFIS tool can be used to **gather farm gate data, GPS data points on the ground, manage field agricultural trainings and communicate with field staff, managing operations for farmer groups and collectives, end-to-end traceability for farm production, and to process and receive digital payments** through mobile money services provided by MNOs. Although OFIS is used in 21 countries, in Côte d'Ivoire it is specifically used in the cocoa, coffee, rubber, and cashew nut value chains. A final example from Côte d'Ivoire is the application Katchilè, a tool used by the Barry Callebaut cocoa value chain company and developed by SAP. Specifically, **Katchilè is a geo-traceability application used for tracing cocoa beans from Ivoirian farmers back to the warehouse. The tool can be used to assess both community and individual farmer sustainability and needs and can be used to provide support to farmers through a digital farmer system**. Since its launch in 2016, the company plans to roll out use of the application to 65,000 Ivoirian cocoa farmers. These tools can be used by private enterprises, farmer collectives, groups, or individuals to manage activities throughout the entire length of an agricultural value chain, including mobile money payments.

Source

GSMA. (2017). Opportunities in agricultural value chain digitisation. Learnings from Côte d'Ivoire. Accessed June 18, 2020.

Box 8. The Nigerian and Kenyan Mobile Money experiences: a comparative analysis

Mixed Success of Mobile Money rollouts in two major African Economies

Mobile Money has transformed the lives of populations in developing countries in a remarkably short amount of time, contributing to increased financial inclusion for millions of formerly unbanked individuals and households. Although MM was unheard of before 2007, by 2017 there were 277 million registered MM users in Sub-Saharan Africa, with 100 million regular users. **The most well-known MM success story is M-Pesa in Kenya, with over 80% of the country currently using the platform since its pilot launch in 2005** for transactions including peer-to-peer money transfers, airtime purchases, bill payments, payments to merchants for non-telecommunications goods, and even salary payments. However, similar efforts to jump-start the **MM sector in Nigeria have not been as successful to date, with active users of MM platforms in 2016 comprising only 1% of the Nigerian population**. To understand the differences in the MM adoption and use between these two countries, it is intuitive to look at the respective socioeconomic and regulatory frameworks in which they evolved.

Mobile Network Operators (MNOs)

Mobile Money platforms were introduced in **2011 in Nigeria, several years after news of M-Pesa's success in Kenya began to travel around the continent**. The two countries were at similar points in terms of levels of economic development, mobile phone penetration, rates of financial inclusion, and a need for peer-to-peer payment services to overcome market failures in the financial sector. However, one key difference was the MNO landscape, with Safaricom, the developer and owner of M-Pesa, controlling 70% of the MNO market share in Kenya. The large share of the market controlled by Safaricom was one factor that enabled M-Pesa to reach a critical mass of users beyond which network externalities begin to accrue, wherein the value of the service and the number of services used increase with each additional user joining the network. **Nigeria, on the other hand, has a plethora of MNOs, with no single provider dominating the market** – for example, the MNO with the largest market share, MTN Nigeria, controlled only 47% of the market in 2007.

Regulatory Structure – Central Bank of Nigeria vs. Central Bank of Kenya

The **Mobile Money development and rollout process was regulated strictly by the Central Bank of Nigeria (CBN), which had a much stronger mandate to regulate payments systems than did the Central Bank of Kenya (CBK)** when M-Pesa was being launched in the mid-2000s. Additionally, discussions about Mobile Money systems in Nigeria began just one year after the global financial crisis had begun affecting Nigerian banks. Thus, the CBN was much more wary of unregulated payment systems and wanted to prevent formation of natural monopolies and restore trust in the Nigerian banking system. Because of this, the CBN prohibited MNOs from developing MM platforms, requiring that MMOs be developed only by banks, bank-led consortiums, or non-bank-led consortiums (excluding MNOs). Thus, while the MNO Safaricom was the leading force in the development of M-Pesa in Kenya, MNOs in Nigeria were relegated to a supporting role as mere technology providers. As an MNO, Safaricom was able to make use of its existing wide network of airtime resellers to roll out its MM platform quickly and effectively, thus achieving the critical mass of users necessary to accrue network externalities early on. However, in the case of Nigeria, the non-MNO actors had to build agent networks from scratch, and the time and investment costs were often prohibitive to achieving a critical mass of users. Another factor that helped Safaricom was its strategic link with the Kenyan government, as a 60-40 joint venture between the Kenyan government and the Safaricom parent company, Vodaphone.

Additionally, the **CBN required that all MMOs in Nigeria be interoperable, meaning that users could use any MM platform to access their accounts, irrespective of the service in which they had initially enrolled**. This made it risky for MNOs to invest funds in developing their platforms, as they would have to invest funds in developing a network without knowing if they could recover costs later on. This further lowered the incentive to invest in MMO development in Nigeria as opposed to Kenya, where interoperability was not required. The presence of network externalities in Kenya and their absence to date in Nigeria explains the much slower rate of adoption of MM services in Nigeria as compared to Kenya. As described above, the accrual of network externalities has been hampered in Nigeria by the financial sector regulatory framework and the fragmented nature of the telecommunications sector.

Future Directions

To date, the MM sector in Nigeria has not managed to achieve the critical mass of users required to generate network externalities that can lead to mass adoption of MM services. However, there is some reason to hope that this may change with time. **The CBN in 2015 allowed MNOs to begin playing a more pivotal role in MM service development by enabling MNOs to leverage their existing airtime seller networks to create "superagents",** managing liquidity and recruitment of groups of agents. Additionally, some Nigerian MMOs have been able to secure significant investment funds for development and rollout; most notable among these is Pagatech, whose founder, Tayo Oviosu, had completed an MBA from the University of Southern California and Stanford and was thus able to draw upon his network of Silicon Valley contacts. In some sense, the successful development of MM platforms depends in large part on the idiosyncratic nature and agency of individuals and organizations as they seek investments and formulate and test their ideas. This is also arguably a significant factor in the success of M-Pesa, as founder Nick Hughes was able to secure funding and buy-in from Challenge Funds and other supporters at the opportune time to make his idea come to fruition and turn M-Pesa into a successful venture. In conclusion, the interplay between the abovementioned factors will dictate how long it will take for

the small but growing MM sector in Nigeria to reach a critical mass of users, generate network externalities, and spur mass adoption across the country.

Source

Lepoutre, J., & Oguntoye, A. (2018). The (non-)emergence of mobile money systems in Sub-Saharan Africa: A comparative multilevel perspective of Kenya and Nigeria. Technological Forecasting & Social Change, 131, 262-275.

3.4.3. MM and social protection programs

The implementation of social protection programs based on cash transfers in developing countries often bumps into a range of transportation, logistics, uncertainty, information and opportunity costs related to the physical delivery of cash to program recipients. In 2012, the "Better than Cash Alliance"[28], a partnership of policymakers, companies, donors, and development agencies aimed at promoting the adoption of digital payment systems for public transfers, was launched. If the objective of shifting to digital public transfers through bank transfers or smartcards is realistic and achievable in high-income or emerging economies provided with developed telecommunications and financial infrastructures, the context of many low-income countries may be improper for using sophisticated digital payment technologies. Many Sub-Saharan African countries indeed lack effective telecommunications, financial, and administrative infrastructures necessary for viable social protection programs to be delivered through this type of e-payment mechanism.

In this context of poorly developed public infrastructure and insufficient government administrative capacity, MM represents an alternative vehicle for G2P cash transfers, inasmuch it fulfills certain conditions. First, the network of MM agents must be dense enough to ensure that transfer recipients can access agents at low cost. Second, MM-based transfers must be protected from leakages to MM agents who are likely, in the same way as public agents, to capture transfers for personal enrichment. We present below one of the few evidence-based studies conducted in a developing country setting on the benefits and pitfalls of public transfers based on MM systems.

Aker et al (2016b) used a randomized experiment to disentangle the effect of an unconditional cash transfer program implemented through various delivery mechanisms on poverty reduction in Niger. This social protection program, which was implemented in response to the 2009-2010 drought-induced food crisis in the country, consisted of delivering unconditionally and on a monthly basis a $45 US cash envelope to female household members in 96 villages under one of the three delivery settings: (1) manual cash transfer delivery; (2) mobile transfer delivery (m-transfer); and (3) manual cash transfer plus an m-transfer-enabled mobile handset. With these three settings, the authors can separate the effect of receiving the money through m-transfer from that of receiving the transfer manually and possessing an m-transfer-enabled mobile phone.[29]

Manual cash transfers, the benchmark delivery mechanism in the study, face a range of obstacles which generate high transaction costs. First, armored vehicles had to travel long distances, sometimes traversing insecure zones, to deliver individual cash envelopes at distribution centers. Second, the personal delivery of envelopes implies rather significant logistics and travel costs, since recipients had

[28] https://www.betterthancash.org/

[29] Because of the humanitarian nature of the intervention, there is no control group of households who did not receive anything from the program, so that the authors cannot compare the effect of receiving money through m-transfer to the situation of not receiving money.

to be informed of the date and location of their cash pickup and in some circumstances had to incur significant time and monetary costs to travel to the payout location to receive their payment.

By contrast, the second delivery setting consisted of using "Zap", an m-transfer system in Niger rolled out in 2010[30], to send transfers to program recipients. Under this setting, recipients were notified by text message that their money could be withdrawn at the nearest Zap agent, inducing an important reduction in cash delivery costs. However, using Zap for transferring money faced three important challenges: (1) less than 30% of households owned a mobile phone before the intervention; (2) program recipients had to be trained on how to use the technology; (3) as Zap was implemented only a few months before the intervention, the network of Zap agents available for m-transfer recipients to pick up their cash was sparse. Thus, in addition to delivering the cash, the program also had to provide households with mobile handsets, train them on use of m-transfer systems, and push the operator to expand its network of Zap agents.

With the third delivery setting, consisting of giving the cash envelope manually together with providing a mobile phone allowing households to use the m-transfer system, the authors were able to identify the impact of the m-transfer mechanism compared to the manual mechanism. They find that all households who received a cash transfer used the money for immediate consumption needs, and that those who received the money through Zap increased household food diversity and quality compared to control groups (treatments 1 and 3). Interestingly, this effect seems to hold even six months after the intervention. They stress that these results are partly explained by the decrease in distance travelled and in time saved by households receiving the money electronically, and by increased bargaining power of females within households. Regarding this last mechanism, the authors find that the m-transfer was not observable by male household member(s), which allowed women to temporarily take advantage of this informational asymmetry and to spend more money on their children's welfare.

3.4.4. Mobile money and cash transfers on education

In SSA, improving educational outcomes, especially those of girls, is a priority (SDGs 4 & 5). However, rural African households often lack the necessary financial resources to send their children to school, especially when school fees are not subsidized, and the opportunity costs of school attendance are high (e.g. during harvest seasons or when agricultural commodity prices are high). To keep their children in school, interpersonal transfers are commonly solicited by households from relatives often located in distant cities or regions (the donors), which implies long travel times to deliver the money personally, or are subject to diversion if a third party is charged with delivering the money. In addition to these transaction costs, the distance between transfer recipients and donors creates a moral hazard regarding the way the money has been spent by the former, which may reduce amounts sent by the latter (Adida et al, 2018). Last, the observability of manual cash transfers by members of the donor's social network may incite her to reduce amounts sent in order to alleviate peer pressure for redistribution (Di Falco et al, 2018, 2011; Adida et al, 2018).

By reducing travel costs and risks of leakage and by softening peer redistributive pressure, an MM-based school fee payment system could leverage "sleeping" interpersonal transfers and subsequently increase school attendance. However, such a system cannot address by itself issues related to information asymmetries between transfer issuers and recipients. We present below the main insights drawn from a pilot program, described in Adida et al (2018), which consisted of developing a system of

[30] Developed by Bhartia Airtel company, formerly Zain company. Zap's functioning principle is the same as M-Pesa's.

MM-based school fee payments designed to reduce the abovementioned transaction costs, information asymmetries and peer redistributive pressure.

The recent uptake in mobile phone ownership in rural Benin has led Adida et al (2018) to develop an MM-based payment system of secondary school fees intended for rural households in Kalalé[31], a remote and low-resource municipality in the country, and implemented over the 2015-2016 academic year (see Box 9). At the time of the study, Kalalé's public secondary school had 1,870 students, charging them fees amounting to approximately $25 US from grades 10 to 12. The authors observed that more than 80% of females and 35% of males were abandoning school between grades 9 (subsidized) and 10 (unsubsidized), and that 40% of surveyed students reported difficulties in paying school fees. Prior to the intervention, MM adoption was very low, and consequently, implementation of the intervention was backed by an NGO to promote diffusion of the digital payment system.

The program developed an MM-based payment system, the Prêt-à-Payer (PaP) system, combining three technologies:

(1) **an MM platform**, compatible with MTN's platform MoMo, allowing donors to choose the school (among registered schools), the student ID, the amount to be sent, and the payment purpose. The money is transferred to the school's MM account, which is associated with the school's formal bank account.
(2) **a transaction tracking software**, recording every transaction made on the platform and allowing parents and school administrators to obtain standardized and timely information on school finances.
(3) **an SMS-based messaging platform**, facilitating communication between students, parents, donors and school administrators.

During the implementation phase, the authors gathered information on 629 students from grades 9 to 12 and obtained contact information for 662 donors around the country. Of these 662 donors, they were able to interview 241 of them, spreading the word about the PaP system and inviting them to registration events. Of the 241 abovementioned donors, 236 attended registration events, along with 125 additional individuals who had not been contacted directly. In the pilot phase, the school received a total of approximately 250 euros from only 15 donors through 23 transfers intended for 18 students. This slow diffusion of the technology and the low participation of donors resulted in only 3% of school fee subscription needs being covered, and of the 23 transfers made, 16 targeted students reported having no difficulties paying school fees. However, when combined with in-person payment transactions recorded by the end of school year[32], this low contribution of PaP-based fee payments corresponds to nearly 12% of the total school fee payments recorded on the platform.

The authors stress that the low diffusion of this pilot project is imputable to technological misconceptions and constraints on MM transactions posed by the operator MTN, by the distance of many donors to the MM infrastructure, and by the missing regulatory framework necessary for schools to be able to process MM transactions. These difficulties suggest that (1) such an MM platform should be market-neutral, i.e. not be developed in partnership with an exclusive mobile-phone provider; (2) school bank accounts should be legally and technologically compatible with MM account ownership;

[31] A municipality of around 170,000 people, mostly dependent on the agricultural sector.

[32] In general, school fee payment is not systematic in Benin, and when payments do occur, in-person school fee payments are often made at the end of the year, before the exam period.

(3) the MM infrastructure, i.e. donor registration and MM agent network, should be dense and have a wide enough extent to cover remote rural areas where donors could be located.

3.4.5. Mobile money and salary payment

As previously stated, the development of mobile money to channel public and private cash transfers responds to the needs of reducing costs and risks induced by moving cash from one place to another, when the banking sector cannot assume this role. For this very reason, MM appears to be a viable technology to process salary payments in various developing countries, characterized by insecure physical environments and/or lacking transportation and financial infrastructures. However, up until now, the deployment of MM-based salary payment systems has been scant in the developing world.

In Liberia, a post-conflict economy where the abovementioned transaction and insecurity costs are high, a digital public payroll system based on MM has been successfully deployed in the Liberian school administration by Mobile Solutions Technical Assistance and Research (mSTAR, see Box 10). A similar system has been implemented by Roshan, the largest Afghan telecommunications operator, to process wage payment in the Afghan police administration. Mobile-based payrolls can also be a useful technology for the private sector, since many private firms face the same logistic, travel, and opportunity costs as public administrations. Such a mobile digital payroll system has also been adopted by the private sector in Afghanistan and assessed in an empirical study conducted by Blumenstock et al (2015). Their main findings are presented below.

To our knowledge, there is scarce empirical evidence on the effect of such a payment system on organizational efficiency and employee welfare. A field experiment conducted in Afghanistan by Blumentstock et al (2015) provides interesting findings on the benefits of the transition from a cash-based salary system to an MM-based payroll system for a private company and its employees. The benefits of such a digital payroll system are expected to be high in Afghanistan, given the high distrust in an underdeveloped banking sector, the prevalence of corruption in the public and private sectors, and high transport and insecurity costs. The authors used a randomized control trial (RCT) consisting of randomly assigning a mobile salary payment system based on M-Paisa, the MM platform developed by Roshan and Vodafone, to a subset of employees of a large private company. Employees in the treatment group therefore received their salaries through MM and could use their balance to make money transfers, to save money, or convert it into cash money with M-Paisa agents. Employees in the control group were treated in the same way as those in treatment group, the only (observable) difference being that they were paid in cash. The authors conducted some 2,000 surveys with the firm's staff and gathered administrative data to measure the impact of this system on the firm's cost management and on employee welfare.

On the firm's side, their findings stress that the adoption of mobile salary payments was a cost-saving operation, as it enabled an 89% reduction of local financial staff costs and a 53% reduction of transfer costs/fees, while only increasing financial staff costs by 20% (a $200 US increase) at their headquarters. Overall, adopting the mobile payroll system technology enabled a 50% reduction in the total cost of delivering salaries. From the operator side, the payment system adoption increased airtime purchases by around $2 US per employee-month, which could incite M-Paisa to lower its system registration tariffs if the system were adopted at a larger scale.

From the employee's side, the study results indicate that the adoption of the mobile payroll system increased employee savings on their MM accounts, corresponding to an average stored value of $30 US (20% of average monthly salary). However, the authors do not find evidence of an increase in total savings amounts, suggesting that MM has been a substitute for informal ways of saving money. Apart

from this effect on saving mechanisms, the authors did not find any evidence supporting that the payment system adoption changed employee's daily lives, because employee perception of increased physical security, experience of corruption, and consumption levels remained the same after transition to the mobile payment system. Interestingly, the authors found that at the beginning of the intervention, those benefitting from the digital payroll system reported delays in mobile salary delivery. The explanation was that some M-Paisa agents did not have sufficient liquidity to convert all e-salaries into cash money. Here again, the coverage, density and good functioning of the MM agent network is a critical precondition for any successful MM-based transfer system.

3.4.6. Main lessons

Taken together, this group of studies suggests that MM, by promoting interpersonal financial transactions and channeling more formal banking services, can be a very effective means of improving MM users' financial inclusion and resilience to shocks, and ultimately moving people out of poverty. These benefits are more pronounced for women and female-headed households, which suggests that financial inclusion through mobile money might be more effective at fostering women's socioeconomic empowerment than is microcredit (Banerjee et al, 2015). Therefore, while this study highlights the benefits of delivering cash transfer programs through mobile rather than manual transfers, their effectiveness relies on having necessary MM infrastructure coverage: mobile phone diffusion has to be large, especially in rural areas where the travel costs are the highest, and the MM agent network has to be dense and wide-reaching. Because these requirements were not met before the program implementation in Niger as described above, the intervention induced high fixed costs related to the digital transfer distribution system setup.

In a nutshell # 5: mMoney and cash transfers

Technologies

Mobile money, mobile banking

Usages

Government-to-person (G2P), person-to-person (P2P) transfers

Stakeholders

Farmers, firms, rural households, women, government

Mechanisms

Financial transaction cost reduction

Travel cost reduction

Transaction (including insecurity) cost reduction in salary payments in conflict areas

Targeting cost reduction in social protection transfers

Informational asymmetry reduction between MM users and the government

Impacts

Consumption smoothing during adverse shocks through precautionary saving and risk-sharing

Increased per capita consumption and reduced poverty prevalence

Improved access to formal credit and saving services

Improved allocation of labor and capital

Empowerment of women using MM

Suggested increase in children's school attendance and lower migration in households using MM

Improved administration and firm cost-efficiency

Factors of success/failure

Penetration of the technology (mobile phones in particular)

Size of the mobile money infrastructure network (MM agents and platform registration locations)

Box 9. Implementation Steps for the Prêt-à-Payer School Fee Digital Payment Platform in Benin

1. **Stakeholder meetings**: Initial meetings were conducted to assess project feasibility and stakeholder support for the project. Follow-up with all stakeholders was done at the time of the pilot program launch. Stakeholders include government officials, the Ministry of Education, school administrators, parents' associations, and MTN, the MNO acting as mobile provider partner for the project.
2. **Student surveys**: Each student over 13 years of age was interviewed at the start of the 2015 school year to obtain the following information: community of origin, mode of school fee payment, difficulties encountered, and contact information for their donors. Contact information for 662 donors was collected – most were parents, but some were friends, former teachers, or other relatives.
3. **Donor outreach**: The team attempted to contact all donors, with a maximum of three attempts allowed according to IRB regulations. 241 donors were contacted and interviewed successfully, informing them about the PaP platform, inviting them to register and to attend registration events if they needed help enrolling, and conducting a brief survey.
4. **Embedded donor survey experiment**: One objective of the pilot study was to administer a survey experiment aimed at understanding the kinds of messages that are likely to incite donors to use the platform and digitally pay for school fees. Donors were randomly assigned to one of three treatments: (1) Peer effect – donors were given a message telling them that they were part of a community of donors using the mobile money platform to pay for school fees, to see if this would induce greater adoption of the platform; (2) Altruism – donors were told that if they used the platform, the project team would make a donation to CEG-Kalalé school, and donors could choose whether this donation would go to the general school fund, school library, campus enclosure, or computer center; (3) Combined peer effect and altruism – donors were given both the peer effect and altruism messages to evaluate whether the combined effects of both treatments would induce an even higher adoption rate.
5. **Registration events**: Several registration events were held between October and December 2015 in the pilot region and surrounding areas to help potential donors register and learn how to use the payment system. MTN SIM cards were purchased and distributed to donors who did not already have one, and a credit incentive was given to those who attended an event. Out of the 241 donors contacted by the team, 236 attended a registration event, along with 125 other individuals who heard about the events by word of mouth.
6. **Monitoring transactions**: The project team was able to monitor transactions remotely once the system was in place, working with the CEG-Kalalé administration team and the school accountant to help him record data, access information, and cash out the school's account as needed.
7. **Testing of messaging platform for communication and fundraising**: The messaging platform was tested on two separate occasions. The first time, the platform was used to communicate the fall fee payment deadline to donors, and the second time, it was used to announce new access codes after the MTN platform migrated in December 2015.

Retrieved and summarized from Adida, Claire L., Chabi Bouko, Adam, Verink, Alex, Chockalingam, Ganz, & Burney, Jennifer. (2018). Pilot of a mobile money school fee payment system in rural Benin. PLoS ONE, 13(6), E0198240.

Box 10. The mSTAR Program in Liberia

Context

Civil servants in many developing countries, including teachers in Liberia, have traditionally had to incur significant time, travel, and financial costs to withdraw cash from the bank after being paid or to cash-in a paper check. This is due to market failures in the financial services sector such as **high transaction costs, information asymmetries, and undeveloped market structure**. For example, in Liberia, 90% of roads are unpaved and 60% of ATMs are concentrated in the capital region of Monrovia. According to teachers surveyed within a USAID-led administration reform GEMS project[33], **Liberian teachers spend on average 15% of their salaries in cashing their checks, incurring costs for travel, lodging, food, bank fees, and bribes**, not to mention the high opportunity cost associated with time-consuming travel. Under the traditional payment system, wherein teachers have to visit a brick-and-mortar bank location, many teachers only cashed out their payments once a month, with some even reporting visiting a bank only once every other month or once a year in extreme cases. Bank lines are often hours or even days long, and liquidity constraints lead to frequent cash shortages. **When teachers take multi-day trips to collect their salaries, classes are unable to be held and students are denied education during these periods**. The GEMS project survey mentioned above showed that teachers typically spend two days on average to collect their paychecks and up to one week cashing it in at the bank.

The mSTAR mobile-money (MM) technology

In 2016, the Mobile Solutions Technical Assistance and Research (mSTAR) project, led by FHI360 and funded by USAID, partnered with the Government of Liberia to develop a pilot MM-based public salary payment system rolled out to 67 teachers located in the Nimba county. According to the mSTAR project**, teachers saved 13.5 hours on average by using this MM salary payment system for the first payment alone during the pilot phase**. Teachers also saved on financial expenses as well; while average costs of traveling to a bank and the associated transportation, bank fee, food, and lodging expenses were significant, at $2,227 LD, with mSTAR these costs plummeted to $188 LD ($2 US). This represents an **84% reduction in the cost of receiving salaries for Liberian teachers using the platform.**

Scaling Up and Future Directions

The scaling-up of this project to the entire public administration in Liberia could improve its efficiency and save millions of dollars spent by the administration in fees, payroll manager salaries, and travel and logistics costs related to cash-based wage payments. As of January 2018, the mSTAR program had reached 3,187 teachers and 803 health workers in 14 counties of Liberia. At the program's outset, Lonestar MTN, one of the largest telecommunications providers in Liberia, was the only partner authorized by the Liberian government to disburse mobile salary payments to workers. Having a single MM provider in the country created a lack of options and suboptimal quality of services offered to users, according to some workers surveyed about the Lonestar MTN MM service. This situation was ameliorated in November of 2017, when the government of Liberia allowed a second telecommunications provider, Orange to use its MM service, Orange Money, to pay health and education workers. Having two mobile providers in Liberia offering MM wage payment services created increased competition, resulting in lower prices and increased number of service points where workers can receive their payments. **This increased level of competition also has the potential to spur additional improvements in service delivery, including payment product integration, user-friendliness, value-added services such as market and weather information and health messaging**, and new, innovative products to promote a greater degree of financial inclusion across the country. And as of 2018, over 34% of Liberians had subscribed to mobile money services, suggesting that the possibilities for further scaling-up of MM wage payments are great.

Source

Bustinza, E. (2018). Revolutionizing Payday: Mobile Money's Transformative Impact on Liberia's Public Workers. NextBillion. Accessed June 19, 2020. Available: https://nextbillion.net/revolutionizing-payday-mobile-moneys-transformative-impact-on-liberias-public-workers/

mSTAR. (2016). mSTAR/Liberia: Mobile Salary Payment Factsheet, Nimba County. Accessed June 19, 2020. Available: https://mstarproject.files.wordpress.com/2015/11/mstar_liberia_2-pager_mobilemoney.pdf

[33] https://mstarproject.files.wordpress.com/2015/11/mstar_liberia_2-pager_mobilemoney.pdf. See also

4. Discussion: lessons learned and implications for design of future interventions

Digital technologies are network goods whose utility derived by users and socioeconomic impacts depend: (1) on the network size and on the quality of interconnections (Crémer et al, 2000; Bjorkegren, 2019); and (2) on the importance of market failures, transaction costs and infrastructural deficits (Aker, 2017). In particular, the leapfrogging potential of mobile telephony in Africa has been unparalleled. When the distance between people is immense due to missing road and wireline infrastructures and where market and state failures in the provision of public services are profound, mobile technology is the easiest way for Africans to connect to each other, reduce information asymmetries, and lower transaction costs. As a result, digital initiatives based on mobile phones have multiplied in the region, allowing many Africans to get access to basic public services such as education, health, or financial services.

Digital technologies have proven to be instrumental to address market failures in public service delivery, but their potential for scaling up is potentially hampered by the large digital divide in SSA, characterized by the low penetration of digital technologies in remote areas and among the poorest and most vulnerable segments of African societies. The first part of the report stresses that the potential of digital technologies will be fully unleashed if policymakers are able to address persistent obstacles to ICT access that have long remained structural handicaps in African economies: allowing affordable access to energy, extending the landline backbone infrastructure and the mobile Internet network, improving educational attainment, and reducing gender inequalities. As a result, the low penetration of Internet and related technologies in (West) African countries precludes large-scale sophisticated usage of digital technologies, particularly usages based on Internet, artificial intelligence, cloud-computing, the Internet of things, or big data. Innovations based on these technologies offer promising perspectives for public service provision and development in Africa, but their bourgeoning nature and limited scale does not allow rigorous assessment of their impacts as of yet.

In this regard, the literature review of evidence-based studies proposed in the second part of the report analyzes digital technologies' impacts on various areas of public service provision. While this review is not exhaustive, we attempted to cover salient public services that have benefitted from digitization in the Sub-Saharan Africa, i.e. agricultural, education, health, and financial services. Therefore, this review does not cover all areas of public services, such as taxation, digital identities, or public utilities management, but instead provides in-depth analyses of key selected digital interventions, highlighting their strengths and weaknesses, emphasizing the main market failures addressed by digital technologies, and identifying the local conditions that permitted or undermined their impact.

The findings presented in this report stress that **the most basic usages of digital technologies, especially mobile technologies, can yield the greatest benefits for the poor**. First, empirical studies show that **information dissemination** through mobile phone networks significantly reduces informational asymmetries between agricultural markets and farmers, health centers/workers and patients, public school administrations and stakeholders, and money transfer senders and receivers. Therefore, these studies suggest that **mobile ownership through affordable telecommunications tariffs, mobile network coverage through investment in the terrestrial infrastructure, and familiarization with mobile usage through adult-training modules are three key ingredients that can unleash the digital dividends of mobile phones, when they are used as an information search engine**.

Second, these studies highlight that **mobile phones can be a revolutionary payment platform that reduces a wide range of transaction costs prevailing in African markets, with a proven positive**

impact on consumption smoothing, risk sharing, access to credit and saving services, and therefore on financial inclusion. Mobile money should also play an increasing role in social protection programs and salary payments (government-to-person transfers), even though this usage has not yet been subject to systematic and rigorous evaluations in Sub-Saharan Africa (Gelb et al, 2020). In addition to the three previously mentioned conditions for mobile phone impact maximization, mobile-money system deployment in Kenya and other African countries stress the importance of the size of mobile money infrastructure networks – i.e. mobile money agents and registration points – for mobile money to be widespread and successful at promoting financial inclusion. The mobile money infrastructure extension in West Africa is a critical and necessary step towards the massive adoption of mobile money and the generalization of digital identification, necessary for the emergence of mobile banking and digital social protection programs, as can be seen in Kenya (Gelb et al, 2020). The second companion report, "*The State of Digital Financial Services in Francophone West Africa",* provides an in-depth analysis of the diffusion of digital financial services in West Africa and the rest of SSA.

Therefore, to have a significant impact on access to public services and poverty reduction**, policymakers should first focus on basic, affordable, user-friendly digital technologies**, **in particular those based on mobile technologies, and on simple usages such as transmitting market information through phone calls or text messages, or enhancing financial inclusion through mobile money**. However, the African connectivity infrastructure network does not yet offer the conditions for effective and efficient delivery of public services through 3G, 4G or 5G technologies. International connectivity is frequently undermined by telecommunications submarine cable outages, provoking recurrent Internet shutdowns in Togo, Benin, Mauritania, Somalia, Cameroon, Mauritius, Comoros, and other countries (Cariolle, 2018; Cariolle et al, 2019). Terrestrial connectivity infrastructures, especially data centers and IXPs, and energy infrastructures are also particularly missing. On the one hand, most African websites are hosted in foreign data centers, which has a negative consequence on Internet cost and latency, and on the sovereignty of African networks. On the other hand, poor energy infrastructure coverage and frequent power outages represent a critical element of the connectivity puzzle in SSA and a strong impediment to digital public service uptake.

Overall, relevant research in the digital public services field suggests that digital technologies improve public service provision but their diffusion is often hindered by the large fixed costs of related infrastructure, and by the limited digital absorptive capacity of populations (Aker, 2017). **To leverage digital public service provision, decision makers should focus on basic technologies accessible by the whole population, to implement proactive policies that ensure affordable and quality access to digital services, and make significant investments in the telecommunications and energy infrastructure networks**.

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APPENDICES

Appendix A. Digital technologies and agricultural extension in Sub-Saharan Africa

Mechanism/Project	Type of information (prices, techniques, inputs, buyers/sellers, general)	Country	Mechanisms (voice, SMS, internet)	Website
Voice				
Allo Ingenier	General	Cameroon	Voice	http://www.irinnews.org/Report.aspx?ReportId=78408
Banana Information Line	Techniques (bananas)	Kenya	Text-to-speech	http://www.comminit.com
Southern Africa Development Q&A Service	General	South Africa	Voice	
National Farmer's Information Service (NAFIS)	General	Kenya	Voice	
T2M (Time to Market)	Prices, supply	Senegal	Voice, SMS, Internet	http://t2m.manobi.sn/
Millennium Information Centers and Community Parliaments	General	Kenya	Voice, SMS	
Question and Answer Service (QAS) Voucher System	General	Uganda	Voice (ask question), radio, internet	
Kenya Farmer's Helpline	Market prices, weather	Kenya	Voice	
Radio dial-up				
African Farm Radio Research Initiative (AFRRI)	General	Ghana, Malawi, Mali, Tanzania, Uganda	Radio	http://www.farmradio.org
Family Alliance for Development and Cooperation (FADECO)	General	Tanzania	Radio, SMS	http://www.hedon.info/FADECOTanzania
Freedom Fone	General	Zimbabwe	Voice, SMS, internet	http://www.kubatana.net
Infonet Biovision Farmer Information Platform	Techniques	Kenya	Radio	
Information Network in Mande	Techniques	Mali	Radio	
Jekafo Guelekan System for Farmers in Sikasso	General	Mali	Radio	
The Organic Farmer	Techniques	Kenya	Radio, internet, magazine	www.organicfarmermagazine.org
Strengthening the Agricultural Information Flow and Dissemination System	General	Zambia	Radio	
Internet				

Agriculture Research and Rural Information Network (ARRIN) Ndere Troupe	General	Uganda	Internet	https://iicd.org/
Agrovision	Techniques	Nigeria	Internet	
Agricultural Sector Development Programme (ASDP)	General	Tanzania	Internet, SMS	https://www.ifad.org/en/
Collecting and Exchanging of Local Agricultural Content (CELAC)	General	Uganda	Internet, radio, email, SMS	
CROMABU (Crops Marketing Bureau) Project	Prices/buyers/sellers	Tanzania	Telecenter (computers)	https://iicd.org/
DrumNet (Solution)	Prices/buyers/sellers	Kenya, Uganda	Internet	
Eastern Corridor Agro-market Information Centre (ECAMIC)	Prices	Ghana	Email, mobile phones	
E-commerce for nontraditional exports	Buyers, sellers	Ghana	Internet	https://iicd.org/
E-commerce for women	Buyers, sellers	Ghana	Internet	
Enhancing Access to Agricultural Information using ICT in Apac District (EAAI)	Techniques	Uganda	Radio, mobile phones	http://www.comminit.com
Farmers' internet cafe	Buyers, sellers, general	Zambia	Internet	
First Mile Project	Buyers, sellers	Tanzania	Internet	
Fruiléma	Buyers, sellers	Mali	Internet, mobile phones	https://iicd.org/
ICT for Shea Butter Producers	General	Mali	Computers	
Miproka	General	Burkina Faso	Internet (computers)	
Sene Kunafoni Bulon	Buyers, sellers	Mali	Internet (computers)	
Sissili Vala Kori	General	Burkina Faso	Internet (computers)	
TV Koodo: Market price information using web and national TV	Market prices	Burkina Faso	Internet, TV	
Mobile Money Transfers (SMS)				
Mobile Transactions Zambia	Cashless input voucher system	Zambia	Mobile scratchcards	
Mobile Phone Data Collection				
Integrating ICT for Quality Assurance and Marketing	Production quality, buyers	Zambia	Handheld computers	
Research on Expectations about Agricultural Production (REAP)	Weather, pests	Tanzania	Voice	
SMS-Based Extension and Price Information Services				

Agricultural Marketing and Information System for Malawi (MIS-Malawi)	Prices, buyers, sellers	Malawi	SMS, internet, radio	
Agricultural Marketing Systems Development Programme (AMSDP)	Prices	Tanzania	SMS	https://www.ifad.org/en/
Agricultural Research Extension Network (ARENET)	General	Uganda	Internet	
Apps for Africa	Techniques, weather, buyers, sellers	Uganda	SMS	
CELAC	Techniques, weather, buyers, sellers	Uganda	SMS	
Esoko (formerly Tradenet)	Prices, buyers, sellers	Benin, Burkina Faso, Cote d'Ivoire, Ghana, Madagascar, Mali, Mozambique, Nigeria, Tanzania, Uganda, Cameroon	SMS, internet	http://www.esoko.com
Farmers Information Communication Management (FICOM)	Prices, buyers, sellers	Uganda	Voice, SMS, internet, radio	http://www.syngentafoundation.org
ICT support for agricultural literacy	Market prices	Ghana	SMS	
ICT for improving agriculture in Rwanda	General	Rwanda	SMS	http://www.spidercenter.org
Informations sur les Marches Agricoles par Cellulaire (IMAC)	Prices	Niger	SMS	
InfoPrix Benin	Prices	Benin	SMS	
Infotrade Uganda	Prices	Uganda	SMS, internet	
Kenya Agricultural Commodities Exchange (KACE) MIS Project	Prices, buyers, sellers	Kenya	Voice, SMS, internet	
Livestock Information Network and Knowledge System (LINKS)	Prices, buyers, sellers	Kenya, Ethiopia, Tanzania	SMS, internet	Kenya (www.lmiske.net), Ethiopia (www.lmiset.net), Tanzania (www.lmistz.net)
Manobi	Prices	Senegal	SMS	http://www.manobi.net
Makuleke Project	Prices, buyers, sellers	South Africa	SMS	
Network of Market Information Systems and Traders' Organizations of West Africa (MISTOWA)	Prices, buyers, sellers	ECOWAS countries	Internet, radio, email, SMS	
Regional Agricultural Trade Information Network (RATIN)	Buyers and sellers	East Africa	Voice, internet	www.ratin.net
Vodacom Tanzania	Prices	Tanzania	SMS	
SMS Information Service	Prices, buyers, sellers	Zambia, Democratic Republic of Congo	SMS, internet	http://www.farmprices.co.zm/

Système d'Information des Marchés Agricoles (SIMA)	Prices	Niger	SMS	http://ictupdate.cta.int
Trade at hand	Prices	Burkina Faso, Mali, Senegal, Mozambique, Liberia	SMS	http://www.intracen.org/
West African Agricultural Market Information System Network (RESIMAO/WAMIS-Net)	Prices, buyers, sellers	Benin, Burkina Faso, Cote d'Ivoire, Guinea, Niger, Mali, Senegal, Togo, Nigeria	Internet, radio, email, SMS	
Women of Uganda Network (WOUGNET)	Prices	Uganda	SMS	
Xam Marsé	Prices, buyers, sellers	Senegal	SMS, internet	

Source: Aker (2011), updated in 2015.

"Sur quoi la fondera-t-il l'économie du monde qu'il veut gouverner? Sera-ce sur le caprice de chaque particulier? Quelle confusion! Sera-ce sur la justice? Il l'ignore."

Pascal

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