

Public Disclosure Authorized

Public Disclosure Authorized

Public Disclosure Authorized

# Fintech for the Water Sector

Advancing Financial Inclusion for More Equitable Access to Water

John Ikeda and Ken Liffiton

## About the Water Global Practice

Launched in 2014, the World Bank Group's Water Global Practice brings together financing, knowledge, and implementation in one platform. By combining the Bank's global knowledge with country investments, this model generates more firepower for transformational solutions to help countries grow sustainably.

Please visit us at [www.worldbank.org/water](http://www.worldbank.org/water) or follow us on Twitter at @WorldBankWater.

## About GWSP

This publication received the support of the Global Water Security & Sanitation Partnership (GWSP). GWSP is a multidonor trust fund administered by the World Bank's Water Global Practice and supported by Australia's Department of Foreign Affairs and Trade; the Bill & Melinda Gates Foundation; The Netherlands' Ministry of Foreign Trade and Development Cooperation; Norway's Ministry of Foreign Affairs; the Rockefeller Foundation; the Swedish International Development Cooperation Agency; Switzerland's State Secretariat for Economic Affairs; the Swiss Agency for Development and Cooperation; Irish Aid; and the U.K. Department for International Development.

Please visit us at [www.worldbank.org/gwsp](http://www.worldbank.org/gwsp) or follow us on Twitter #gwsp.

# Fintech for the Water Sector

Advancing Financial Inclusion for  
More Equitable Access to Water

John Ikeda and Ken Liffiton

© 2019 International Bank for Reconstruction and Development / The World Bank  
1818 H Street NW, Washington, DC 20433

Telephone: 202-473-1000; Internet: [www.worldbank.org](http://www.worldbank.org)

This work is a product of the staff of the World Bank with external contributions. The findings, interpretations, and conclusions expressed in this work do not necessarily reflect the views of the World Bank, its Board of Executive Directors, or the governments they represent.

The World Bank does not guarantee the accuracy of the data included in this work. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of the World Bank concerning the legal status of any territory or the endorsement or acceptance of such boundaries.

#### **Rights and Permissions**

The material in this work is subject to copyright. Because the World Bank encourages dissemination of its knowledge, this work may be reproduced, in whole or in part, for non-commercial purposes as long as full attribution to this work is given.

Please cite the work as follows: Ikeda, John and Ken Liffiton. 2019. “Fintech for the Water Sector: Advancing Financial Inclusion for More Equitable Access to Water.” World Bank, Washington, DC.

Any queries on rights and licenses, including subsidiary rights, should be addressed to World Bank Publications, The World Bank Group, 1818 H Street NW, Washington, DC 20433, USA; fax: 202-522-2625; e-mail: [pubrights@worldbank.org](mailto:pubrights@worldbank.org).

*Cover design:* Jean Franz, Franz & Company, Inc.

# Contents

<i>Acknowledgments</i>	v
<i>Executive Summary</i>	vii
<i>Abbreviations</i>	xi
<b>Introduction</b>	<b>1</b>
<b>Background</b>	<b>5</b>
Introduction to Fintech	5
Fintech Outside the Water Sector	7
Focus: Urban Water and Sanitation and Irrigation for Smallholder Farmers	9
<b>Water and Sanitation for Urban Households—Overview</b>	<b>10</b>
<b>Helping Urban Households Manage Up-front Costs of Water and Sanitation</b>	<b>11</b>
Use Case 1: Savings to Reduce High Up-front Costs	11
Use Case 2: Financing to Reduce High Up-front Costs	12
Potential Use Case 1: Enhanced Savings Tools for Water and Sanitation	13
Potential Use Case 2: Subsidies for Water and Sanitation Using Blockchain	14
<b>Urban Water and Sanitation Provision by Utilities</b>	<b>16</b>
Use Case 1: PAYG to Address Payment Risk and Expand Access	16
Use Case 2: Utility Payments via Mobile Money	17
Potential Use Case 1: Enhanced Payment Options for Prepaid Standpipes	19
Potential Use Case 2: Linking Utilities and Credit Data to Reduce Risk	20
<b>Urban Water and Sanitation Provision by Small-scale Service Providers</b>	<b>21</b>
Use Case 1: Simplified Accounting and Billing for Efficiency and Creditworthiness	21
Use Case 2: PAYG to Ensure Water Revenue Collection and Network Maintenance	22
Potential Use Case: PAYG for Household Sanitation	24
<b>Smallholder Irrigation</b>	<b>25</b>
Use Case 1: PAYG Shutoff Financing Models to Reduce Up-front Equipment Costs	26
Use Case 2: Rural-focused Commitment Savings to Cover Equipment Costs	27
Use Case 3: Credit Scoring for Farmers—Alternative Data and IoT Irrigation	27
Use Case 4: PAYG Water for Irrigation	28

Potential Use Case 1: New Water Usage Management and Conservation Schemes	28
Potential Use Case 2: Marketplace Platforms with Irrigation Integration	30
<b>The Way Forward</b>	<b>34</b>
Policy Recommendations—Water and Sanitation for Urban Households	35
Policy Recommendations—Smallholder Irrigation	35
<b>Appendix A: Organizations Mentioned</b>	<b>37</b>
<b>References</b>	<b>38</b>
<b>Boxes</b>	
1. Blockchain and Decentralized Ledgers	8
2. The Internet of Things Defined	15
<b>Figures</b>	
1. Challenges in Providing Equitable Access to Water Services	2
2. Benefits of Fintech	3
<b>Tables</b>	
1. Challenges Addressed in Fintech Use Cases	4
2. Examples of Established Fintech Companies	5
3. Applications of Fintech	6
4. Steps for a Prepaid Domestic Water Connection Versus a Standpipe	17



## Acknowledgments

The authors would like to acknowledge the following people for sharing their time and expertise: Sharmista Appaya, Heather Arney, Alexander Bakalian, Beun Chan, Leng Dieb, Kwadwo Gyasi, Rob Hygate, Samir Ibrahim, John Kinaga, William Kingdom, Joel Kolker, Phyrum Kov, Roy Lai, Xiaokai Li, Evelyn Liffiton, Lalima Maskey, Margaret Miller, Samuel Mutono, Regassa Namara, Davith Nong, Francois Onimus, Rajish Sarin, Alexander Sotiriou, Rich Thorsten, Joep Verhagen, Shilp Verma, Daniel Waldron, and Alison Wedgwood.







## Executive Summary

For many low-income households in the developing world, incomes are highly variable and uncertain—this is often a significant barrier to accessing clean drinking water and safe and convenient sanitary facilities. In rural areas, incomes often vary even more, making it difficult for farmers to invest in irrigation for their fields. High up-front costs combined with irregular incomes result in unequal access to water, sanitation, and irrigation.

Households typically can, and should, cover the costs of accessing water resources, but they cannot do this without help. Financial inclusion can help households access water resources. Financial inclusion focuses on ensuring everyone has access to useful and affordable financial products and services, including transactions, payments, savings, credit, and insurance.

There are numerous examples of financial inclusion in the water sector. To help make connection fees more affordable, some water utilities offer installment payment plans. Since the late 2000s, microcredit and other financial services have been explored as tools for helping households access water resources by spreading the cost of an expensive purchase, such as a cistern, latrine, or irrigation system, over time. Because of the positive externalities seen in the water sector, there may be limited scope for subsidy and more active engagement in the market by the public sector. However, the emerging field of financial technology (fintech) can help address barriers to financial inclusion in the water sector while potentially reducing or eliminating the need for subsidy.

Fintech is the application of new technologies to financial services, often by smaller, nimbler firms that focus on providing simple solutions for specific needs of consumers and businesses. Increased smartphone usage and cheap computing power have enabled fintech businesses to thrive. Generally, customer-facing fintech solutions remove friction and lower costs, often increasing speed and adding value versus traditional financial services.

Fintech solutions already address some of the needs of developing-nation households—applications include payments and mobile money, pay-as-you-go (PAYG) models, insurance technology (insurtech), and virtual banks. Solar energy providers have been at the forefront of fintech, integrating a variety of payment plans supported by PAYG shutoff technology into their products. Although marketplace platforms such as Alibaba and Amazon Marketplace were initially developed for urban e-commerce, platforms that serve the distinct needs of smallholder farmers are starting to become a reality.

This paper explores how fintech can support expansion of market-based solutions for water, sanitation, and irrigation, identifying several use cases where fintech is already being used to address financial inclusion and access to water. In addition to ways that fintech can help households access water supply and sanitation services, the paper also examines how fintech can help water utilities serve low-income customers more effectively and assist small-scale service providers in growing their businesses.

## **Water and Sanitation for Urban Households**

Both households and service providers can benefit from fintech applications in water through more cost-effective access for households and greater efficiencies for utilities.

For households, fintech can simplify the task of paying up-front costs such as connection fees or largely eliminate the up-front costs through PAYG models or targeted subsidies. Fintech-enabled commitment savings models offer households another way to manage up-front costs and can be combined with remittance tools to increase households' saving power. Finally, fintech innovations are creating new efficiencies and easier access for micro-finance loans in support of water and sanitation.

Large utilities can benefit from fintech by using PAYG to reduce payment risk, enhance billing systems, and link with credit data to reduce risk and boost revenue. PAYG enhancements are particularly promising for prepaid standpipes, which bring access to clean water to the poorest and often replace higher-cost options from informal providers. Small-scale providers face their own challenges in management and access to finance, and they can benefit from PAYG models as well as simplified accounting and billing systems to increase efficiency and transparency, thus improving their creditworthiness.

## **Smallholder Irrigation**

Although irrigation systems can help smallholder farmers multiply their productivity, the systems are relatively expensive: Farmers incur capital expenses for equipment and operating expenses to fuel pumps, and harvest cycles result in irregular cash flows. Smallholder irrigation technologies such as solar-powered water pumps are rapidly increasing in availability and declining in cost, though cost remains a significant barrier for many farmers. Meanwhile, without effective ground and surface water governance, rapid expansion of smallholder irrigation can lead to water depletion and degradation in water-stressed areas.

Smallholder irrigation solutions can be readily standardized and scaled to a large number of customers, creating ideal conditions for fintech applications. By reducing transaction costs and expanding access in rural areas, fintech can support the growth of smallholder irrigation through PAYG business models and savings tools, which some vendors are beginning to explore. Irrigation systems must be considered within the broader context of a farmer's business; therefore, innovations such as alternative-data credit scoring for farmers and marketplace platforms for agriculture value chains can significantly improve farmers' opportunities to access irrigation. In addition, fintech may help in managing water resources more effectively.

## **The Way Forward**

Although global access to water, sanitation, and irrigation is increasing, without increased financial inclusion, many will continue to be left out. Fintech tools can enhance the effectiveness of financial inclusion for water; as costs continue to fall and technologies mature,

new use cases are likely to emerge. In particular, the increasing accessibility of smartphones for the poor will continue to open up new possibilities.

As new fintech tools are developed, they can readily be adapted to fit the water sector. However, taking advantage of fintech for water requires a coordinated effort between the public and private sectors. Governments can provide a supportive policy environment for fintech, subsidize broadly beneficial tools such as credit bureaus or marketplace platforms, and promote financial literacy. Donor agencies can support policy development and encourage cross-sector collaboration with fintech companies, as well as providing funding for social enterprises combining fintech and water. Utilities have an unprecedented opportunity to take advantage of fintech tools to improve efficiency and lower costs. Finally, fintech companies stand to benefit from the business opportunities associated with resolving current inefficiencies in the water sector and broadening financial inclusion for water.





## Abbreviations

API	application programming interface
ATM	automatic teller machine
B2B	business-to-business
B2C	business-to-consumer
CRM	customer relationship management software
fintech	financial technology
GPRS	general packet radio service
IC	integrated circuit
insurtech	insurance technology
IoT	Internet of Things
KYC	know your customer
MFI	microfinance institution
NFC	near-field communication
OTP	one-time password
PAYG	pay-as-you-go
POS	point of sale
RFID	radio frequency ID
SME	small and medium enterprise
SMS	short message service
USSD	unstructured supplementary service data
UPI	Unified Payments Interface
US\$	U.S. dollar
WASH	water supply, sanitation, and hygiene



## Introduction

For many low-income households in the developing world, incomes are highly variable and uncertain. Informal-sector workers often have temporary cash flows and endure long periods with little or no income; only about 2 percent of low-income families in the informal sector enjoy relatively steady incomes throughout the year (Collins et al. 2009). This poses a multitude of challenges for these households and is often a significant barrier to accessing clean drinking water and safe and convenient sanitary facilities. In rural areas, incomes often vary even more because of the seasonality of agricultural markets, making it difficult for farmers to invest in irrigation for their fields.

In both urban water and sanitation and irrigation, a large up-front investment is often required—typically in the form of a connection fee to link the house to the utility’s network or a large asset to be purchased, such as a septic tank or irrigation system. Although some households are simply too poor to afford these costs, many more households could, but they are unlikely to have enough savings on hand to make this investment.

This up-front cost, combined with highly irregular incomes, is one of the main drivers for the high levels of inequality in access still seen in the water sector. A World Bank study (2018) on inequality of access to water, sanitation, and hygiene (WASH) services in 18 countries found that the poor tended to have substandard access. For example, in India, only 6 percent of households in the bottom income quintile have access to piped water, compared to 56 percent in the top quintile; in Ethiopia, wealthier households are four times more likely to have a direct water source than poor homes. In Ecuador, 56 percent of the people in the bottom 40 percent have access to improved sanitation, whereas 83 percent of the top 60 percent have access (World Bank 2018). Meanwhile, most smallholder farmers do not use irrigation at all; in Africa, only 5 percent of cultivated land is irrigated (International Finance Corporation 2018).

When households cannot make this large up-front investment, they often receive more expensive but inferior quality service or are excluded entirely. In many countries, urban households who cannot afford a utility connection are forced to turn to roving fleets of unregistered tanker trucks for water. The cost to fill a cistern or a small container might be 10 to 20 times higher than the formal tariff charged by the utility, and the water may be untreated or poorly treated, resulting in illness. Households without the resources to invest in a high-quality hygienic latrine or pay for a sewerage connection might decide to simply dig a simple pit latrine or defecate in the open, which has significant public health implications. Farmers unable to afford irrigation equipment must forgo this investment, resulting in much lower yields.

In many countries, public subsidies fill the gap between the cost of service and what households can afford to pay (see figure 1). This is typically justified by the strong positive externalities of water-related services. Increased levels of access to clean drinking water and improved sanitation, for example, have significant public health impacts. However, targeting has a history of being poorly managed and regressive in the water sector. For example,

**FIGURE 1. Challenges in Providing Equitable Access to Water Services**

Water subsector	Key challenges in providing equitable access to services	Typical role of public sector in addressing challenges	Opportunities for financial sector to address challenges
Urban water supply and sanitation: regulated utilities	<ul style="list-style-type: none"> <li>- Serving low-income customers may be expensive</li> <li>- Low-income customers lack resources to pay connection fee to access services</li> </ul>	<ul style="list-style-type: none"> <li>- Subsidizing capital expenditures and ongoing operating expenses</li> <li>- Subsidizing connection fees and tariffs</li> </ul>	<ul style="list-style-type: none"> <li>- Provide savings products for connection fees</li> <li>- Provide installment payments for connection fees</li> <li>- Provide additional bill payment channels</li> </ul>
Urban water supply and sanitation: small informal service providers	<ul style="list-style-type: none"> <li>- Service providers are typically informal and unregulated</li> <li>- Service providers lack access to credit</li> <li>- High cost of services</li> <li>- Large up-front purchase (for example, cistern or latrine) requires cash outlay</li> </ul>	<ul style="list-style-type: none"> <li>- Minimal engagement from public sector; support for formalization and subsidy in some countries</li> </ul>	<ul style="list-style-type: none"> <li>- Provide loans for investment and working capital to small-scale service providers</li> <li>- Provide microloans to households</li> <li>- Provide savings products to households</li> </ul>
Smallholder irrigation	<ul style="list-style-type: none"> <li>- Smaller vendors may lack access to credit</li> <li>- High up-front cost of systems prohibitive for smallholder farmers</li> </ul>	<ul style="list-style-type: none"> <li>- Subsidizing equipment for smallholder farmers</li> </ul>	<ul style="list-style-type: none"> <li>- Provide loans for investment and working capital to vendors</li> <li>- Provide microloans to households</li> <li>- Provide savings products to households</li> </ul>

subsidies to urban water utilities often benefit wealthier and more politically connected neighborhoods. Even if subsidies for connection fees and other up-front costs could be directed with more precision to the households who most need them, the total cost would be massive. In Ghana, for example, providing a quality hygienic toilet to every household in the country that needed one would cost more than US\$2 billion (Steel 2018).

Donor funding is insufficient to cover these needs—globally, donors provide about US\$17 billion per year for the water sector, much of it as concessional financing (Winpenny et al. 2016) Domestic resources, including taxes, are another potential source of subsidy, but tax collection and allocation remain a challenge in many countries. Households typically can, and should, cover the costs of accessing water resources, but they cannot do this without help.

Financial inclusion can help households access water resources. Financial inclusion focuses on ensuring everyone has access to useful and affordable financial products and services, including transactions, payments, savings, credit, and insurance. Financial access simplifies daily tasks and helps families and businesses plan for everything from long-term goals to unexpected emergencies.

Examples of financial inclusion in the water sector exist in many countries. For example, to help make connection fees more affordable, some water utilities offer installment payment plans, allowing customers to spread the cost over several months’ worth of bills. However, many utilities struggle to offer payment plans because of cash flow issues, exacerbated by outdated billing systems, which results in low collections.



Since the late 2000s, microcredit and other financial services have been explored as tools for helping households access water resources by spreading the cost of an expensive purchase, such as a cistern, latrine, or irrigation system, over time. Borrowers can take out a loan for an asset and then pay back the loan over time—with interest. Conversely, safe and accessible savings accounts allow households to save up for purchases. However, many financial institutions have been reluctant to enter the water sector because of high perceived risks and low levels of profitability.

Because of a long history in many countries of market distortion and inefficient targeting of subsidies, advocates for financial inclusion generally support market-based interest rates and an emphasis on full cost recovery. Subsidies are typically strongly discouraged. Despite this, because of the positive externalities seen in the water sector, there may be some limited scope for subsidy and more active engagement in the market by the public sector. Subsidies to financial institutions to offer services to households too poor to pay market rates can expand coverage, particularly in more remote areas and informal urban settlements. Subsidies to households can kickstart water sector-focused financial services by building a critical mass of early adopters, demonstrating the viability of the market. Guarantees can make the risk profile of water loans more palatable to lenders.

The emerging field of financial technology (fintech) can help address barriers to financial inclusion in the water sector while potentially reducing or eliminating the need for subsidy (see figure 2). Fintech increases operational efficiencies, making existing products more viable, while also supporting new approaches to making access to water more affordable—in many cases, without the need for customers to take loans. At the same time, fintech tools can enhance the operations of utilities, which can translate to greater access and affordability. Large utilities can benefit from using fintech tools to reduce risk and enhance billing systems to increase collections, whereas small-scale providers can benefit from PAYG models customized for their services, as well as simplified accounting and billing systems, thus leading to increased efficiency and transparency.

**FIGURE 2. Benefits of Fintech**

Benefits of fintech	Implications for financial inclusion in the water sector
Reduced costs	- Financial products previously not viable may be profitable
Increased availability of services	- Increased convenience can result in greater demand - Remote populations are easier to reach
Reduced friction and increased speed	- Increased convenience can result in greater demand
New services enabled	- Alternatives to asset ownership (PAYG) become viable - More efficient bill payment channels

Note: fintech = financial technology; PAYG = pay-as-you-go.

**TABLE 1. Challenges Addressed in Fintech Use Cases**

Challenge	Use cases
Helping urban households manage up-front costs of water and sanitation	<ul style="list-style-type: none"> <li>• Savings to reduce high up-front costs</li> <li>• Financing to reduce high up-front costs</li> <li>• Enhanced savings tools for water and sanitation</li> <li>• Subsidies for water and sanitation using blockchain</li> </ul>
Urban water and sanitation provision by utilities	<ul style="list-style-type: none"> <li>• PAYG to address payment risk and expand access</li> <li>• Utility payments via mobile money</li> <li>• Enhanced payment options for prepaid standpipes</li> <li>• Linking utilities and credit data to reduce risk</li> </ul>
Urban water and sanitation provision by small-scale service providers	<ul style="list-style-type: none"> <li>• Simplified accounting and billing for efficiency and creditworthiness</li> <li>• PAYG to ensure water revenue collection and network maintenance</li> <li>• PAYG for household sanitation</li> </ul>
Smallholder irrigation	<ul style="list-style-type: none"> <li>• PAYG shutoff financing models to reduce up-front equipment costs</li> <li>• Rural-focused commitment savings to cover equipment costs</li> <li>• Credit scoring for farmers—alternative data and IoT irrigation</li> <li>• PAYG water for irrigation</li> <li>• New water usage management and conservation schemes</li> <li>• Marketplace platforms with irrigation integration</li> </ul>

Note: PAYG = pay-as-you-go.

Through a series of use cases, the following paper presents several ways that fintech is being used to support financial inclusion in the water sector and outlines directions for future exploration by policymakers, donors, service providers, and fintech entrepreneurs (table 1).

# Background

## Introduction to Fintech

Put simply, financial technology (fintech) is the application of new technologies to financial services, often by smaller, nimbler firms that focus on providing simple solutions for specific needs of consumers and businesses, rather than providing a full suite of financial services. Although the original conception of fintech was largely focused on retail customers, and seen as a direct challenge to incumbent banks, fintech companies have diversified to offer a range of consumer and business products that may compete with, complement, or directly support banks' operations. Examples of established fintech companies that may be familiar to readers are in table 2; there are many more startups that serve their respective niches.

The growth of fintech has been enabled, to a large extent, by high uptake of smartphones, which made up 57 percent of mobile connections in the world in 2017 and will reach 77 percent by 2025. Mobile internet usage is expected to increase by 1.75 billion subscribers between 2017 and 2025; most of the increase will come from China (about 350 million new users), India (330 million), and Sub-Saharan Africa (280 million) (GSMA 2018). Meanwhile, the price of smartphones continues to fall, with some models available for less than US\$50.

At the same time, the cost of computing is falling by approximately 50 percent every three years, thanks to technological advances as well as the growth of cloud computing, which provides fintech companies with the computing power they need to scale while removing capital costs from the equation (O'Connor 2014).

Generally, fintech solutions aim to be customer-centric—removing friction, lowering costs, and often increasing speed and adding value versus traditional financial services:

- **Reduced costs:** The cost of executing a transaction via a fintech tool can be substantially lower than via legacy systems, in part because of removal of intermediaries, potentially reduced technology costs using shared infrastructure, and increased competition facilitated by lower barriers to entry where regulatory environments allow. For example, though international remittances have historically been plagued by high costs, the field is increasingly crowded with fintech companies that provide remittance services at much lower costs than banks and traditional remittance companies; furthermore, regulatory technology (regtech) companies are poised to lower regulatory compliance costs for

**TABLE 2. Examples of Established Fintech Companies**

Company	Country	Business
Ant Financial	China	Digital financial services ecosystem (payments, loans, banking); division of Alibaba
Credit Karma	United States	Credit reporting and monitoring
Stripe	United States	Payment processing for small businesses
TransferWise	UK	International transfers
Venmo	United States	Mobile payments; division of PayPal

**TABLE 3. Applications of Fintech**

Application	Emerging market example
<b>Payments and e-wallets/mobile money</b> allow customers to store funds and make transfers at minimal cost using their mobile phones.	Mobile money has caught on in markets where existing bank infrastructure was particularly lacking—for example, M-Pesa in East Africa—and increases the efficiency of payments and domestic remittances, while providing a safe store of value for millions of customers in those countries.
<b>PAYG models</b> break down the cost of a product or service into small, manageable payments, converting a fixed, up-front expense into a variable expense and eliminating the need for credit checks.	PAYG first came to mobile airtime and has driven the massive growth of telecoms; now, the concept is being applied more broadly—for example, M-KOPA, which allows customers to use solar home systems without large up-front expenditures.
<b>Insurtech</b> enables automated underwriting and digital policy issuance, particularly of microinsurance for the developing world.	Low transaction costs have allowed insurance companies to issue micropolicies that would not have been practical using traditional underwriting; this increases access to insurance while allowing the insurers to collect valuable data and graduate some customers to larger policies and other products.
<b>Virtual banks</b> eliminate infrastructure (branches, ATMs, and so on) and operate solely via an app and website to deliver more convenient, lower-cost banking services to their customers.	Although such banks have initially targeted the urban middle class, as smartphone penetration increases, these banks can expand their customer bases and agent networks without geographic limitation, eventually bringing full banking coverage to rural areas.
<b>Marketplace platforms</b> eliminate friction and connect buyers and sellers for B2B or B2C transactions.	Although such platforms started in urban e-commerce, today, platforms such as Taobao (China) are starting to expand the marketplace concept to rural areas.

Note: ATM = automatic teller machine; B2B = business-to-business; B2C = business-to-consumer; insurtech = insurance technology; PAYG = pay-as-you-go.

remittance providers in more tightly regulated markets. These conditions may exert pressure on banks to reduce their charges, an indirect benefit to customers who do not use fintech solutions.

- **Reduced friction and increased speed:** In the absence of technology, financial transactions may involve middlemen or geographic challenges that raise costs and lower convenience. For example, in the case of domestic remittances, in the past, customers would have needed to make a bus journey to deliver cash (or depend on a third party), but now they make instant transfers via mobile money in many countries.
- **Increased access:** Fintech solutions are generally accessible anywhere a mobile network is present—3G data networks already cover more than 80 percent of the world’s population (Voltornist 2014). Furthermore, low technology costs and user-friendly interfaces allow for the rollout of agent networks that provide cash-in and cash-out services and reach customers who may not have the necessary mobile phone or technological savviness to access fintech solutions directly.
- **Added value through new services:** In some cases, fintech opens the possibility of offering services that are practical only where costs are low. For example, microinsurance involves the issuance of large numbers of small insurance policies with very small premiums,

which are often spread out over a series of micropayments. By removing overhead and facilitating small transactions, fintech solutions make microinsurance possible. Meanwhile, increasingly alternative sources of data are used to produce credit scores and make lending decisions that previously would have required an expensive underwriting process and possibly collateral as well.

## Fintech Outside the Water Sector

Although fintech is just starting to address the water sector, fintech solutions already address some of the needs of developing-nation households. Applications of fintech include payments and mobile money, pay-as-you-go (PAYG) models, insurtech, virtual banks, and marketplace platforms (table 3). These existing tools can be used to solve payment and financing issues across all utility providers, with model adjustments in some cases to address the unique challenges of increasing access to water and sanitation.

**PAYG models:** Home solar energy system providers have been leaders in applying fintech to service provision, integrating PAYG shutoff technology into their products. Such implementations include

- An electronic payment method, typically mobile money
- Equipment that can shut the system down if sufficient payment has not been made
- Management software that is designed to handle billing and service provision as well as at least the basic accounting of the service provider

These systems have gained traction in East Africa, setting the foundation for solar applications in the water sector. M-KOPA pioneered the model in Kenya, selling home solar systems based on a daily payment from a mobile money account over the course of a year. If the customer falls behind on payments, then the system shuts down, providing a clear incentive to pay. After one year of payments, the customer owns the home solar system. Founded in 2011, M-KOPA sold more than 500,000 solar home systems through the end of 2017. The basic system allows customers to power LED lightbulbs and a radio as well as recharge mobile phones and other USB devices; an upgraded system includes a solar-powered television.

**Marketplace platforms:** Many of the first marketplace platforms were for e-commerce and largely urban-focused. For example, Alibaba started with business-to-business (B2B) trade, and Amazon Marketplace started as business-to-consumer (B2C). However, platforms that serve the needs of the rural poor are starting to become a reality.

From its roots as a wholesale marketplace platform, Alibaba grew to provide financial services and facilitate other parts of the trade ecosystem. Eventually, it expanded outside the cities to reach the half of China's population who live in rural areas through its Taobao marketplace platform. Rural Taobao facilitates both traditional marketplace e-commerce with a focus on rural-to-urban sales, as well as trade in some agricultural goods; the company operates a network of more than 30,000 rural service centers and aims to reach 150,000 villages by 2021. In addition to connecting buyers and sellers, the platform's built-in data analytics give sellers

insights to manage production and inventory—for example, showing farmers which fruits sell well by season.

Rural-first platforms are emerging as well. For example, Sentinel Chain is a financial services marketplace that promises to unlock additional capital for smallholder farmers using blockchain technology (box 1) to provide a reliable way to collateralize and insure livestock; it is being piloted in Myanmar and Bangladesh. Provenance of livestock is difficult to prove, and insurance fraud may result. Banks may, in turn, be less willing to make livestock loans and could encounter difficulty borrowing to fund their livestock lending. Sentinel Chain solves these problems by registering livestock on a blockchain using tamper-proof radio frequency ID (RFID) tags that assign a unique ID to each animal—this allows insurers to be certain they are writing a policy on one specific animal and, in turn, allows financial institutions to make a loan against that animal with the assurance that it is unique and fully insured. Ultimately, Sentinel Chain aims to build upon this initial platform to support a more comprehensive range of financial services for the rural unbanked.

#### **BOX 1. Blockchain and Decentralized Ledgers**

Although much of the attention paid to blockchain has focused on Bitcoin and other cryptocurrencies built on the technology, the power of blockchain lies in the fact that it stores an immutable record of transactions, assets, contracts, and so on that can be decentralized and that it runs on a network of independent computers whose owners are incentivized to contribute the necessary computing power to run the network. A decentralized blockchain cannot be manipulated by any of the players in the system—once a record, or *block*, is added to the chain, it cannot be altered.

This *decentralized ledger* concept makes a variety of applications possible that would have once required middlemen, but now can be executed as “trustless” transactions—that is, the users of the system have assurance of the validity of any transaction and can, therefore, transact with complete strangers in an open and transparent manner. In the case of currencies, trust in a fiat currency is based on trust in the government that issues it and its associated economy, whereas trust in a cryptocurrency such as Bitcoin is based on the decentralized ledger that underpins it, which contains a public record of all the transactions that have been executed in that cryptocurrency.

In addition, applications built on certain blockchains such as Ethereum support *smart contracts* that execute certain outcomes such as a payment based on predefined events. For example, climate-indexed crop insurance could track weather data and automatically pay out based on a threshold being hit.

Furthermore, smart contracts are used to create *tokens* that run on top of blockchains and can serve as the medium of exchange for a given project, eliminating the need to create new blockchain infrastructure for the project. Investors who purchase the tokens bet that in a successful project, the finite supply of a token will increase in value.

## Focus: Urban Water and Sanitation and Irrigation for Smallholder Farmers

Consumer-focused fintech solutions typically offer low cost and speed as their key benefits and, therefore, have the greatest impact in scaled solutions with broad customer bases, high transaction volume, and a high degree of standardization. Furthermore, sufficient internet coverage is useful, though some fintech tools have offline functionality that reaches well beyond areas with mobile data coverage.

Higher transaction volume activities can produce a lower cost per transaction and create a greater benefit to fintech-enabled solutions. For example, though a fintech approach to paying for land title registration may be useful, it removes far less friction for the average user than smart card payment for public transportation.

Other conditions are useful but not necessary. For example, access to the power grid is helpful, but the low power requirements of hardware for consumer usage of fintech (smartphones, smart cards, and so on) means that solar energy is sufficient. A moderately technologically literate, smartphone-using population is useful for direct access to more advanced fintech solutions, but where these conditions are not met, solutions can be delivered via unstructured supplementary service data (USSD) and short message service (SMS) features available on all mobile phones, as well as by agent networks. Indeed, some of the fintech-enabled PAYG solutions presented in this paper could be used via an agent network by customers who are illiterate and have no smartphone; irrigation solutions are often solar-powered and thus independent of the power grid.

Within the water sector, there are two areas where fintech is most directly relevant:

1. **Urban water and sanitation**, where standardized technology can serve universal needs across a given urban area, mobile data coverage is near 100 percent, and smartphone penetration is significant and growing.
2. **Irrigation for smallholder farmers**, who have a variety of small-scale irrigation technologies from which to choose but face varying barriers in terms of up-front costs and running costs, depending on the technology. Needs may be more diverse in different geographic areas, but solutions are largely standardized and scalable within a given region.

This paper explores how fintech can support expansion of market-based solutions for water, sanitation, and irrigation, identifying several use cases where fintech is already being used to address financial inclusion and access to water. In addition to ways that fintech can directly support households, the paper also examines how fintech solutions can help utilities improve efficiency to reach more customers, support small-scale service providers in growing their businesses, and enhance existing water and sanitation lending programs offered by financial institutions.



## Water and Sanitation for Urban Households—Overview

The world's towns and cities are growing rapidly. By 2050, the total urban population is expected to double, reaching 6.4 billion people. Traditionally, municipal governments or publicly owned and managed utilities have had the mandate to provide water supply and sanitation services to households and commercial customers. However, water utilities struggle to adapt to rapid urbanization, with a network of smaller, informal service providers filling unmet demand. Governments and utilities are challenged to balance the need for services to be financially self-sufficient with the critical need for poor households to have access as well. The consequences of low coverage rates are dire.

Although 70 percent of urban households in the developing world have access to clean water, only 40 percent of households in informal settlements have access, and many rely on shared connections such as standpipes, boreholes, or water kiosks. In the informal settlements of Nairobi, Kenya, less than 20 percent of households has a direct water connection. Less than 15 percent of the urban poor in Asia and Africa have access to sewerage (International Housing Coalition 2018). Inadequate access to water supply and sanitation leads to serious public health risks; without clean water, handwashing declines sharply, germs and disease spread rapidly, and a lack of sanitation facilities results in fecal contamination of water resources. In addition to immediate public health risks, there are also longer-term impacts on human capital and economic growth (World Bank 2017).

Both households and service providers can benefit from financial technology (fintech) applications in water. For households, fintech can simplify the task of saving or borrowing to pay for up-front costs, such as connection fees, or largely eliminate the up-front costs through pay-as-you-go (PAYG) models or targeted subsidies. Large urban utilities can benefit from fintech by using PAYG to reduce payment risk, enhance billing systems, and link with credit data to reduce risk and potentially provide an additional revenue stream. (Although it is beyond the scope of this paper, large irrigation utilities may benefit from similar solutions.) Small-scale providers can benefit from PAYG models customized for their services, as well as simplified accounting and billing systems to increase efficiency and transparency, thus leading to improved financial viability and creditworthiness.



## Helping Urban Households Manage Up-front Costs of Water and Sanitation

Accessing water supply and sanitation in urban areas often requires a high up-front payment from households. To cover the cost of labor and materials needed, utilities require new customers to pay a connection fee to link their households to the water or sewer network. Connection fees in the developing world can range from as little as US\$15 to as much as US\$782, and these fees are often quite substantial (Department for International Development 2006). For poor households with highly variable incomes and expenses, even a small connection fee can be a barrier to access. In urban areas with sufficient space for pit latrines or septic tanks, households might need to pay a contractor several hundred dollars to build sanitary facilities.

Pay-as-you-go (PAYG) models can shift the payment structure from a large up-front cost to an ongoing service fee paid for usage and infrastructure costs, with financing costs rolled into the ongoing payments. However, in many countries, PAYG has not received widespread acceptance by customers or is not offered by utilities. Although PAYG can expand access down market to a broader range of customers, those who previously qualified to receive services on credit may object to paying up front; meanwhile, utilities incur an up-front cost for systemwide implementation of the necessary metering equipment and billing software. In these cases, households may be able to use traditional financial products, such as savings accounts and consumer loans, to make the cost of a connection fee or construction of on-site sanitation more accessible. Increasingly, financial institutions are adapting microfinance for water and sanitation, and a strong push for greater financial inclusion has made savings accounts more accessible for low-income households. Financial technology (fintech) enhancements can increase the efficiency and availability of these products to help more urban households access improved water supply and sanitation.

### Use Case 1: Savings to Reduce High Up-front Costs

Savings is a straightforward way to meet a future up-front cost; however, this is easier said than done, particularly in developing countries. The ability to save in a regulated, secure institution is still lacking for many people, and even where banks are available, the poor may prefer to save “under the mattress” because of low financial literacy or lack of trust in formal financial institutions. However, this approach to saving has significant risks and does not earn interest. In addition, there are competing demands on such savings, particularly if the savings are known to family members and friends. Even if the saver has a specific goal in mind, there are often pressures or temptations to spend the money on something else. Fortunately, there are ways to make savings easier and more accessible to the poor while helping earmark funds for a specific future purpose—in this case, increased access to water and sanitation.

In Ghana, a toilet savings program has used mobile operator AirtelTigo's mobile money platform to help Accra residents save to purchase subsidized toilets, in partnership with local government offices. The World Bank-financed Greater Accra Metropolitan Area Sanitation and Water Project provides a partial subsidy for the construction of household toilets in low-income areas. Government health officers identify potential beneficiaries and register them for the program. The beneficiaries use the AirtelTigo savings program to make deposits toward their required contribution via mobile money. Beneficiaries can make direct transfers via their phones, at a mobile money agent, or through the health officer. Once deposits have been made, they cannot be spent on other items or easily withdrawn. This represents a form of "commitment savings," a financial tool that allows the saver to designate funds for a specific purpose only. Other examples of commitment savings include lay-away and retirement savings accounts.

At its launch, the program was cash-based; mobile money was later introduced to reduce the risk of transporting large amounts of cash and to manage large transaction volumes more effectively. As of 2018 the system is short message service (SMS)-based, and back-end processes are largely manual. Despite the technical limitations, in its first two years, the scheme has mobilized about US\$800,000 for the construction of nearly 4,000 toilets. In collaboration with AirtelTigo, the project team is now exploring how to fully automate the system through a smartphone app for health officers. The program demonstrates that households can and will save to invest in sanitation. Furthermore, mobile money can be used to make saving for sanitation safer, more efficient, and more convenient.

## **Use Case 2: Financing to Reduce High Up-front Costs**

Although models such as PAYG and commitment savings can reduce customer reliance on loans to finance water, sanitation, and irrigation needs, in some cases, loans are the best or only option available to customers. Customers may use general-purpose loan products to pay for water and sanitation, but microfinance lenders are increasingly offering loans targeted specifically to aspects of households' water and sanitation needs, including

- Water network connection fees;
- Water filters; and
- Latrine construction, improvement, or repair.

In Bangladesh, sanitation entrepreneurs partner with microfinance institutions (MFIs) such as ASA and BRAC to offer their potential customers loans for the construction of latrines. WaterCredit, a program of Water.org, has supported MFIs in 11 countries to roll out new water and sanitation loan products, with more than US\$1 billion in loans disbursed. VisionFund Cambodia (now part of Woori Bank) first piloted loans for latrine construction and now offers a comprehensive range of water supply, sanitation, and hygiene (WASH) loan products; it is moving to implement electronic payment.

As with other microfinance products, these WASH loans stand to benefit from applications of fintech that can lower costs, reduce processing time, and improve the customer experience. For example, MFIs in several countries where sufficient financial services infrastructure exists have implemented electronic disbursement of loans, whether to bank or mobile money accounts. Automated credit analysis can improve the accuracy of lending decisions and lower the cost of borrowing for qualified customers. More advanced systems even provide customers with the option of customizing loans to their personal cash flows, allowing the customer to draw a graph of their desired repayment schedule on a touchscreen, with loan amortization calculated automatically in the background.

MFIs are benefitting from the rise of fintech on the back end as well, in many cases moving to cloud-based core banking systems such as Mambu and Oradian, which eliminate much of the MFIs' information technology (IT) overhead and support new technologies such as field operations via tablets.

## Potential Use Case 1: Enhanced Savings Tools for Water and Sanitation

### Building upon Commitment Savings Programs

Although the AirtelTigo commitment savings program streamlines payments using mobile money and is accessible to any customer because it is SMS-based, the flexibility of the system is, at the same time, limited by the SMS technology. The growth of smartphone usage, especially in urban centers, provides the opportunity to add more user-friendly tools.

One example of a smartphone app commitment savings program is the goal save feature of Timo, a digital bank in Vietnam. Timo walks the customer through a series of simple questions:

1. *What are you saving for?*

The app asks the customer to type in the specific name of the thing they want to buy to make the user more committed to the goal.

2. *How much do you need, and when?*

3. *How often do you want to make contributions (daily/weekly/monthly)?*

4. *When do you want to start contributing?*

The app then suggests the recurring contribution amount that will get the customer to their goal by the desired date, or the user can choose their own amount. Contributions are automatically swept from the user's current account into their goal save account. Although this example uses an interest-bearing savings account, the same concept could be applied to mobile money accounts. Because the program is customized to each customer's needs, contributions are more likely to match personal cash flows, increasing a customer's chance of successfully reaching their savings goal.

Revolut, a digital bank based in the United Kingdom, introduced vaults in 2018. Users opt to allow each purchase to be rounded up to the nearest dollar, pound, euro, and so on, and

the difference is deposited in a separate savings account. This savings account is comparable to the AirtelTigo program and Timo examples in that it has a stated savings goal and regular deposits, though contributions to the vault are less regular and not time-bound. The logic behind vaults is that siphoning off a few cents is not noticeable to the customer on a daily basis but accumulates over time.

### **Earmarking Remittances for Water and Sanitation**

Although fintech providers have brought lower costs and greater convenience to both international and domestic remittance markets, senders of remittances often worry that the funds may not be used for the purposes they intended. Therefore, some remittance providers allow senders to restrict the usage of the remittance:

- Digicel Tonga has integrated remittance and bill payment systems, allowing remittance senders abroad to make bill payments directly on behalf of recipients in Tonga; for example, they can earmark their remittances for educational purposes by making a bill payment to a school (KlickEx Pacific 2012).
- Interbank Peru has applied a slightly different model to allow remitters to finance the purchase or construction of a home; by making six months of remittance payments equivalent to a mortgage installment, the remitter can qualify themselves or their relatives for a mortgage (Banco Internacional del Perú 2018).

A combination of remittance earmarking and commitment savings technology could be applied for water and sanitation needs in conjunction with service provider agreements as applied in existing commitment savings schemes. This approach opens up the possibility of marketing water and sanitation products and services to overseas relatives of potential customers, who can then advocate for improved water and sanitation. Using similar technology, government transfers could be earmarked for water and sanitation needs as well.

### **Potential Use Case 2: Subsidies for Water and Sanitation Using Blockchain**

Targeted subsidies for water often require a heavy administrative burden and may not reach those who need them most. To reduce overhead and ensure transparency, blockchain tokens could be used to subsidize service providers directly, with smart contracts disbursing funds automatically and transactions irrevocably recorded to show the usage of the funds. For example, a targeted subsidy token could be used to incentivize water and sanitation providers to reach underserved areas, with progress tracked via Internet of Things (IoT)-enabled meters and data fed back to trigger smart contracts (box 2). This would allow for real-time tracking of the subsidy's effect, as well as adjustment and gradual phase-out as appropriate. With sufficient integration of systems across a municipality, smart contracts could additionally govern payment of household-level subsidies based on previous payments received by the household.

Another potential application of blockchain for subsidies comes from eWaterPay, which is developing the eWater token to fund community water projects. The token would be

## BOX 2. The Internet of Things Defined

**The Internet of Things (IoT)** consists of a broad range of devices that contain low-cost sensor technology and communicate across the internet to provide rich data, allow for remote control, and interact with other IoT devices for smart automation. For example, consumers can control appliances and optimize energy usage through IoT-enabled “smart homes,” drive connected cars, and ask questions of “smart assistants” such as Amazon’s Alexa. Low-cost sensors are enabling consumers to track their health and fitness with connected monitoring devices.

In industrial applications, similar advancements in sensor technology allow for detailed monitoring of production lines; for example, allowing machines to track performance and call for repairs before a breakdown occurs. In agriculture, wireless sensors can capture data on climate, soil, fertilization, and irrigation; for example, soil sensors and climate sensors could communicate with irrigation systems to optimize the amount of water being used on a crop.

purchased with donor funds and distributed to community stakeholders, who could use it to purchase prepaid water equipment directly from manufacturers; this would largely eliminate the need for cash to be handled locally. Next, the system would allow for transparent monitoring and maintenance of the resulting PAYG community water projects.

For water and sanitation lending, subsidies could be integrated directly into the lending process via subsidy credits and purchased from financial institutions by donors to reduce the cost of loans, with the provenance of funded projects (toilets and water connections) verified via blockchain tools, much as in the Sentinel Chain livestock example mentioned previously. Some lenders have already pioneered a similar model without blockchain, using the carbon credit market. XacBank sells carbon credits to reduce the cost of loans for clean-burning stoves and energy-efficient tents in Mongolia. LifeStraw has applied a similar model to water filtration products, which reduce carbon emissions in Kenya, where wood is traditionally burned to heat water for purification.



## Urban Water and Sanitation Provision by Utilities

The high cost of providing service is the main constraint preventing utilities from expanding access. Piped water and sewerage infrastructure is expensive to construct, and moving water through these pipes is an energy-intensive process. Utilities often face political pressure to set tariffs below full cost-recovery levels, even though the rates poor households pay to informal service providers may already be several times higher than the utilities' full cost-recovery levels. If tariffs do not cover the full cost of providing service, each new customer added actually costs the utility money, dampening the incentive for managers to expand coverage, particularly to poorer neighborhoods.

In addition, many utilities struggle with billing and collections. Typically, utilities provide postpaid service—the customer consumes water over the course of the billing period then receives a bill, based on either the amount consumed or a flat fee. Even if a utility is able to charge tariffs that cover costs, if the utility is not able to generate a bill and then send it to the customer, or if customers do not pay their bills in a timely manner, then ongoing financial viability is at risk. External pressures from politicians and the media can drive high nonpayment rates, and antiquated and inefficient billing and collections processes at many utilities exacerbate the problem.

### **Use Case 1: PAYG to Address Payment Risk and Expand Access**

In developed and developing countries alike, utilities face a shortfall between the amount of water they pump into their systems and the amount of water for which they ultimately receive payment. The difference is a combination of leakage, theft, and ineffective billing, where customers are unwilling or unable to pay or do not even receive a bill in the first place.

In developing countries, utilities experience an estimated 27 billion cubic meters of non-revenue water each year—60 percent is lost because of leaks, and 40 percent is delivered to customers with no corresponding revenue to the utility, which is twice the rate of commercial loss experienced by water utilities in developed countries. These commercial losses are estimated to cost utilities in developing countries US\$2.6 billion per year (Kingdom, Liemberger, and Marin 2006).

The simplest way to address commercial losses is by ensuring that customers are billed for the water they consume and to then improve on collections of those bills. In addition to improving billing and collections processes for postpaid accounts, pay-as-you-go (PAYG) approaches can address commercial losses as customers pay in advance for water they plan to consume. Additionally, by reducing nonpayment risks, PAYG encourages utilities to expand access more widely, connecting customers regardless of their perceived creditworthiness.

At the core of any PAYG implementation are smart meters that contain technology to shut down if the customer has not made sufficient payment. Although this method works for electricity (the customer can use a flashlight or light a candle), there is no substitute for

water; in fact, affordable access to clean water is recognized as a human right by the United Nations. Therefore, many utilities ensure that poorer customers have access to water by implementing rising block tariffs (where the first few cubic meters used each month are free) or offering free “basic” water with a capped allowance per day. In addition, current smart meter technologies may not function well on networks with inconsistent pressure and low water quality (Heymans, Eales, and Franceys 2014).

Customers may top up their meters by adding value to a prepaid smart card, which is then used to top up the meter or “over-the-air” in the case of meters that contain general packet radio service (GPRS)—that is, mobile network—technology. In either case, funds can be added via mobile money, agents, or bank transfers.

PAYG water implementations for households come in two distinct versions, each of which addresses a different customer segment:

1. **Prepaid individual domestic connections**, which help individual households manage the risk of consuming more water than they can afford
2. **Prepaid standpipes**, which provide the community access to water, circumventing intermediaries who may mark up the price of water significantly and restrict access

Although there is a significant up-front cost for the utility in implementing PAYG water, prepaid standpipes, in particular, allow utilities to reach underserved poor households, as well as providing sufficient sales volume to offset investment and running costs. For example, as of 2014, the water utility in Kampala, Uganda, operated 1,600 prepaid standpipes with plans to add 3,000 more (Heymans, Eales, and Franceys 2014).

From the customer perspective, using a domestic prepaid water connection or a prepaid standpipe involves similar payment steps (table 4).

However, PAYG technology alone does not satisfy customer needs without a robust network of service points to top up credit. Improved billing processes, which may be applied to either PAYG top-up or postpaid water, are the way forward.

**Use Case 2: Utility Payments via Mobile Money**

Where utilities do provide services, billing and payment may be paper- and cash-based and, therefore, inconvenient and potentially time-consuming for the customer. Furthermore, such cash-based systems are unlikely to report to credit bureaus, so even customers who make payments reliably do not gain increased access to formal credit.

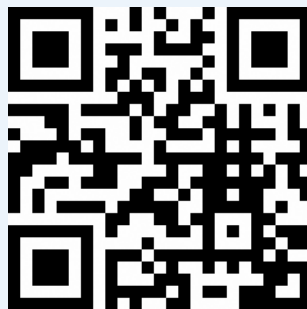
**TABLE 4. Steps for a Prepaid Domestic Water Connection Versus a Standpipe**

Step	Domestic prepaid water connection	Prepaid standpipe
1	Customer is issued a physical tag (token, key, or card) to pay for water.	
2	Value on the tag is topped up with an agent or at a bank, or via mobile money.	
3	The tag is used to top up value on the customer's smart meter, which will continue to run until credit runs out.	The tag is used to activate the flow of water from the standpipe, and the value of the water is deducted from the tag.
4	The tag has zero value until the next top-up, as all credit has been loaded on the meter.	Remaining credit is stored on the customer's tag and can be used at any standpipe in the utility's network.

Although mobile money is one of the oldest, most established financial technology (fintech) innovations, utility providers in many countries have not implemented electronic payment in their systems. As a result, the payment process may be cumbersome for consumers, and the utilities often miss out on revenue from uncollected bills. Payments via mobile money offer a solution, providing greater ease of use for the customer while increasing the percentage of bills successfully collected by the utility. Mobile money is not yet universal, but usage is increasing rapidly, such that, eventually, most customers will have a mobile money account or a traditional bank account, with urban populations leading the way. For example, the 2017 Global Findex survey found that mobile money penetration in Sub-Saharan Africa had doubled in three years and utility bill payment with mobile money had doubled in Kenya and Brazil in the same period.

With rapidly growing urban populations and stressed water supplies, China must manage its water resources carefully, and it has seen significant advances in water metering and bill payment. In the past, utilities sent meter readers to record households' water consumption, but meter readers often would collude with homeowners to reduce their water fees. With the advent of smart meters, whether prepaid meters topped up using smart cards or more advanced models linked to central monitoring and billing systems, this revenue loss is prevented.

At the same time, China has seen rapid growth in mobile payments, which totaled nearly US\$13 trillion per year as of October 2017 (*Xinhua* 2018). WeChat, a multipurpose smartphone app that features messaging and social media as well as payments, allows users to pay utility bills including water, electricity, and internet by linking WeChat to their bank accounts. To pay a water bill, the user can simply scan a QR code printed on the water bill or enter their account number and payment details in WeChat. Mobile payments provide a rich source of data to both WeChat and the utilities, and they give government agencies a convenient way to subsidize water provision to low-income households while reducing the risk that subsidies will be misdirected.



A **QR code** is an advanced type of barcode that contains more complex data than the numbers stored by traditional barcodes. For example, many merchants in China display QR codes that customers can scan with their smartphone cameras to make payments via apps such as WeChat. The QR code above contains the URL for the World Bank website.



### Potential Use Case 1: Enhanced Payment Options for Prepaid Standpipes

A key drawback of prepaid standpipes is the need for customers to carry a physical token, which may be lost or broken. Fintech solutions offer some potential ways for customers to pay directly using their phones and mobile money:

1. Many banks are rolling out a “cardless cash” feature to their automatic teller machines (ATMs). In one version of this technology, the customer uses a smartphone app to select an account and amount for withdrawal and then receives a numeric code to enter at the ATM to withdraw cash, in addition to a one-time password (OTP) sent to their mobile phone. For the relatively low value of a water withdrawal, this process could be simplified to a single code to be entered on a keypad on the standpipe. The bank customer may choose to use “cardless cash” to send money to a friend or relative via the ATM network, as the withdrawal code does not grant access to the customer’s account; similarly, a water customer could use the technology to send somebody to fetch water or to give water to a neighbor who is running low on mobile money.
2. Near field communication (NFC) payment technology in smartphones (“tap to pay”) offers another potential solution; customers could pay by holding their phone up to an NFC payment terminal on the standpipe, rather than using an intermediary token or code. Android smartphones with NFC technology sell for as little as US\$50 in 2018, with prices continuing to fall, and feature phones with NFC are offered for less than US\$25. Mobile money providers in several countries have rolled out support for NFC payments (My Smart Price 2018).

**NFC Payments**

Near field communication (NFC) is an umbrella term for various types of short-range communication using radio waves between devices, most commonly smartphones. Examples of payment systems supporting NFC include mobile money platforms such as TCASH Indonesia and M-Pesa Kenya, as well as the Tez payment platform in India (now a part of Google Pay), which makes instant transfers between most major banks via the national Unified Payments Interface (UPI).

NFC payments may be made phone-to-phone or phone-to-terminal at supporting merchants. For example, two users can transfer money by holding their phones close together. NFC is increasingly integrated into point of sale (POS) terminals, allowing customers to pay by tapping their phone on the POS terminal.

Although NFC technology is reaching an increasingly broad range of phones, including some feature phones, it is not yet included in all phones. One short-term solution is the Google platform’s proprietary “audioQR,” which on cheaper smartphones that lack NFC, uses just the phone speaker and microphone to transmit payment data at audio frequencies inaudible to the human ear.

## **Potential Use Case 2: Linking Utilities and Credit Data to Reduce Risk**

With a shift toward electronic payment methods, utilities gain better data on their customers, which can be used to benefit the customer and utility alike. Customer payment data can be used to produce credit scores, ideally via a multiutility partnership such that a customer's full utility payment behavior is captured. These credit scores could be used to extend consumer loans to customers or sold to financial service providers for combination with additional sources of data, providing an additional revenue source for utilities.

Conversely, utilities can use data from credit bureaus (already up and running in most countries, though coverage of poorer segments of the population may be limited) to make decisions about extending service to new customers—for example, allowing households with good credit to pay their connection fee in installments. This is common in developed countries but depends on an understanding of the importance of a decent credit score, which in turn depends on sufficient financial education in the target market.

## Urban Water and Sanitation Provision by Small-scale Service Providers

Although there are ideally economies of scale in urban water supply and sanitation, a range of small-scale service providers, many informal and unregulated, reach households that utilities and municipalities can't or won't serve. Water kiosks and standpipes, as well as tanker trucks, provide water services to households, particularly in sprawling periurban areas. Rather than having a piped connection in their homes, households pay a private operator to fill small containers or a cistern. In some countries, small-scale providers do operate piped water networks but often find these challenging to manage.

For households without access to flush toilets connected to a sewer network, some use shared toilet facilities operated by private providers, local governments, or community organizations. Others hire small construction firms to build a pit latrine or septic tank system, hiring pumping trucks for desludging when needed.

Most informal providers offer prepaid services—collecting payment before providing a fixed amount of water or emptying a septic tank. Unlike formally regulated utilities, they do not typically face the challenges of customer nonpayment. However, they are also hobbled by weak accounting systems and struggle to access financing, degrading the quality of service provided.

### **Use Case 1: Simplified Accounting and Billing for Efficiency and Creditworthiness**

Small enterprises providing water and sanitation services often lack the technical and managerial sophistication to serve their customers efficiently; their accounting may be simple or nonexistent, creating challenges in billing customers as well as in securing financing from banks, who often view water and sanitation enterprises as high risk.

Fortunately, cloud-based software solutions are increasingly available to address these challenges; these could be coupled with smart meters and broadly available financial technology (fintech) tools to form a “utility in a box” package that could improve operational efficiency and billing reliability while automating accounting, improving the creditworthiness of small service providers.

#### **Water Utility in a Box**

E-Power Cambodia started as a small power company and developed its own management software. It soon realized that other small power companies across Cambodia faced many of the same challenges, and today, its power company management software is used by virtually all the private power companies across Cambodia.

Meanwhile, Cambodia has more than 300 small water providers that operate piped networks in smaller towns and struggle to attract well-qualified staff for management

and accounting. Therefore, E-Power introduced its E-Water software to help these providers; As of 2018, half of small water networks in Cambodia use the E-Water solution.

The software offers accounting, production management (for costing of water), and a billing system that connects to payment networks so customers can pay via mobile money, agents, or banks. Water companies in areas with sufficient internet connectivity can use a cloud-based version of the software, minimizing information technology (IT) costs. In the next phase, the software will work with smart meters, readable within a 1-kilometer radius using a mobile phone, and a module is under development to manage and monitor the piping network.

The E-Water software runs postpaid water businesses because pay-as-you-go (PAYG) models have not proved popular in Cambodia; however, the original implementation of E-Power included PAYG functionality that is still used by a small number of customers. PAYG energy is popular in East Africa, with providers such as Paygee offering cloud-based management solutions for PAYG products that could potentially be adapted to water.

With a cloud-based system to manage billing, accounting, and network management—bringing daily management demands down to consumer-type user levels—small water providers could efficiently reach an increasing range of underserved communities including informal urban settlements. Cloud-based systems would facilitate water businesses running on a microfranchise model, with either the franchisor or local banks providing a line of credit to franchisees in case of surges in demand, requiring additional infrastructure. These innovations could equally be applicable to condominium piped water systems, relieving pressure on the central utility by allowing small local providers to take care of the “last mile” in underserved areas (Melo 2005).

### **Solutions for Small Sanitation Providers**

Although small providers of piped sewerage networks could benefit from a solution similar to the water utility in a box, in practice, most small sanitation providers tend to focus on latrine construction and pumping services. One example of software supporting the installation of toilets comes from Indonesia, where the APPSANI business association is using software to coordinate sanitation service providers with community health workers. The system serves as a centralized customer relationship management (CRM) system that brings in a variety of local sanitation providers and allows the association to track overall progress in sanitation. This type of system could potentially be integrated with payment and financing providers, increasing the viability of the service provider’s business with more efficient payments as well as using information on the provider’s business for small and medium enterprise (SME) lending decisions.

## **Use Case 2: PAYG to Ensure Water Revenue Collection and Network Maintenance**

### **PAYG for Prepaid Standpipes by Small Providers**

Community water taps have long been a popular solution in areas where piped water systems do not reach homes. However, a challenge with community-owned taps providing

“free” water is that many systems break down because there is no cash flow to fund upkeep of the system—or even if there is a cash flow via payments collected by an attendant, the community is often not equipped to effectively manage the business.

Although the basic technology for prepaid standpipes is largely the same as that provided by large water utilities, smaller service providers are implementing prepaid standpipes under varying models:

- eWaterPay acts as an intermediary, setting up prepaid standpipes that tap into an existing utility’s water supply; IoT sensors monitor the flow of water at taps and report to a cloud-based system to manage accounting and maintenance. The company has piloted its model of water distribution in Tanzania, Gambia, and Ghana. Grundfos offers a similar technology, with water kiosks implemented in Kenya.
- Safe Water Network (SWN) sets up independent, locally owned microuilities that operate “safe water stations,” drawing from local water sources in periurban and rural communities across Ghana. They are increasingly moving toward prepaid cards, topped up using mobile money, as well as remote monitoring and management of systems. Sarvajal has implemented a similar model in urban and rural areas of India, with water purification plants managed by local entrepreneurs.

These and similar models can be viable opportunities for small providers in urban informal settlements where the utility lacks the resources or political will to implement prepaid standpipes.

### **PAYG for Household Water by Small Providers**

SWN’s microuilities operate household water connections as well as standpipes; although the hope was that household connections would subsidize the standpipes, initially that was not the reality. SWN’s household connections were originally postpaid, and SWN faced the same collection challenges as larger utilities, collecting just 66 cents out of every US\$1 with staff spending as much as 25 percent of their time chasing down payments. To address the collection issue and make the service sustainable, SWN partnered with CGAP to pilot PAYG service with payment via mobile money (Waldron, Hwang, and Yeboah 2018).

Eighty-nine households in two villages were converted to prepaid smart meters, controlled via short message service (SMS) codes linked to mobile payments. The majority of households already had mobile wallets, and mobile money agents were present in the communities. Customers were at first pleased with the technology, but some were initially shocked by the switch to up-front payment; soon, usage volume dropped as households cut down on waste. However, usage of mobile money steadily dropped, with customers switching back to calling the local SWN operator to come collect their cash. SWN launched an educational campaign in partnership with the mobile phone network, emphasizing the convenience and ease of use of mobile payments, and soon usage rates rebounded, ensuring the sustainability of the service.

Thus, although the switch to PAYG can ultimately benefit small utilities, some educational programs (and potentially some moderate pricing incentives for mobile payment) are needed to cement the change. In urban informal settlements and periurban areas, these lessons may be equally applicable to water networks run by small providers.

### **Potential Use Case: PAYG for Household Sanitation**

Container-based sanitation is an emerging solution for sanitation in densely populated urban areas. Households pay for a standalone toilet that uses sealable, removable cartridges. Once filled, the cartridges are collected and transported to a treatment plant. The use of water level sensors for sanitation applications has been piloted by Sanergy in its network of waterless toilets in informal settlements around Nairobi, Kenya; the pilot used infrared sensors to estimate the fill levels of cartridges in the toilets (GSMA 2017). This technology opens up the possibility of PAYG household toilets and pit latrines. In such a scheme, a service provider would install and service a pit latrine based on a fixed contract term (much as post-paid mobile customers purchase their phones in the United States and several other countries). PAYG billing in this scheme would have two components, with users topping up sufficient credit to meet

- A fixed base amount per week or month, covering the installation and maintenance cost of the latrine; or
- A variable amount based on usage of the latrine, calculated such that the total accrued payment would be sufficient to cover the cost of the pumping truck coming to empty the latrine or, in containerized sanitation models, the cost of swapping out the container.

In addition to managing the payment flows, data from the system could be used to

- Optimize routing of pumping trucks—Loowatt, which operates a network of waterless toilets in Madagascar, is piloting such a routing optimization system (Toilet Board Coalition 2016); or
- Facilitate the service provider's access to SME credit, based on transparency into the performance of the provider's portfolio of latrine installations.

In cases of early termination of the contract, a termination fee would apply to recover the infrastructure cost (in countries with a reasonably effective credit bureau); elsewhere, a deposit would be collected at the start of the contract, though the size of the deposit would ideally be limited to the smallest amount necessary to cover the service provider's risk.

## Smallholder Irrigation

The world's population is expected to grow by another billion people over the next 15 years, with most of this expansion coming from developing countries. By 2030, demand for food is expected to be 34 percent higher than it was in 2010. Feeding the planet will require significant investments in all aspects of how food is grown, with a particular focus on irrigation.

Irrigation has helped reduce prices for key staple crops such as rice and wheat, decreasing the number of people at risk of hunger. In the past, most irrigation development has been dominated by the public sector. Although public investment in irrigation has declined in most countries, it has been replaced or even exceeded by private investment by smallholder farmers and commercial operations. There are significant opportunities to expand smallholder irrigation. In Sub-Saharan Africa, more than 30 million hectares of land is suitable for irrigation by smallholder farmers—potentially benefiting nearly 200 million people in rural areas (Xie et al. 2013). However, as of 2018 only 5 percent of cultivated land is currently irrigated.

Farmers incur capital expenses for equipment and operating expenses to fuel pumps; depending on the market, they may pay for water as well. At the same time, harvest cycles result in irregular cash flows, with crop yields dependent on a number of factors in addition to irrigation. Smallholder irrigation technologies such as solar-powered water pumps and drip irrigation systems are rapidly increasing in availability and declining in cost, though most farmers have yet to benefit due to up-front costs. In addition, pumps are only one component of an irrigation system—depending on the local topography, farmers may need to invest even more to build channels for surface water or dig deep boreholes to access groundwater.

Although irrigation systems can help farmers multiply their productivity and, therefore, incomes, the systems are expensive and often out of reach for smallholder farmers. Many farmers lack the liquid savings needed to purchase an irrigation system, which can often cost thousands of dollars. Rather, the bulk of their assets are in informal and illiquid savings such as land and livestock. Farmers who attempt to finance the purchase will likely struggle to do so. Limited credit history and irregular cash flow linked to the crop cycle prevent many financial institutions from lending to farmers. In addition, crop yields are closely linked to weather patterns and pests, though agricultural insurance products are not widely available in many countries.

Smallholder irrigation solutions can be readily standardized and scaled to a large number of customers, creating ideal conditions for financial technology (fintech) applications. By reducing transaction costs and expanding access in rural areas, fintech can support more effective smallholder irrigation in several ways. First, as with urban water and sanitation, pay-as-you-go (PAYG) business models and savings tools can help farmers access irrigation equipment more effectively. In addition, fintech may be able to help address the emerging challenge of managing water resources for irrigation at scale. At the same time, irrigation systems must be considered within the broader context of a farmer's business; therefore, innovations such

as alternative-data credit scoring for farmers and marketplace platforms for agriculture value chains can significantly improve farmers' opportunities to access irrigation.

The expansion of affordable smallholder irrigation offers tremendous benefit—and also brings significant risk. When not combined with effective ground and surface water governance, expanded smallholder irrigation can lead to rapid water depletion and degradation in water-stressed areas, which can, in turn, lead to confrontation and protests in the absence of clearly defined property rights. Solar-powered irrigation systems reduce operating expenses to essentially zero, making water “free” for the farmer. As a result, farmers may use more than necessary, potentially exhausting groundwater supplies. Developing effective incentives and governance systems to manage this risk will be particularly challenging.

### **Use Case 1: PAYG Shutoff Financing Models to Reduce Up-front Equipment Costs**

Irrigation can greatly increase crop yields, supplying the income farmers need to pay for the irrigation system, but this is possible only if they can overcome the obstacle of the initial cost of the system. Some solar-powered irrigation system producers in Kenya are taking steps to apply PAYG shutoff technology to let farmers pay for irrigation systems over time.

SunCulture has used PAYG shutoff technology to pilot installment payment for its solar-powered irrigation system, such that both the up-front fixed equipment cost and the variable cost of using energy (traditionally petrol) are eliminated and just the cost of the installment remains. However, the immediate shutoff feature that is central to PAYG for solar home systems is less practical here. In the case of home systems, billing is daily, so the system could shut down on any given day if the user does not maintain a prepaid credit balance; however, such irregular irrigation could damage the farmer's livelihood, lessening the chance of payment. Therefore, SunCulture is providing service on a monthly basis and integrating the service with analysis of the broader farming ecosystem, adding value for the farmer. Although the monthly payment is still enforced using the PAYG shutoff technology, the business model is actually an installment payment plan, and payments end after the farmer has paid in full for the equipment, net of financing costs.

KickStart offers solar irrigation systems with multiple payment models supported by PAYG shutoff technology:

1. **Pay for time passed:** Farmers pay a fixed monthly fee.
2. **Pay for time used:** Farmers pay only for each hour that the system is activated.
3. **Hybrid model:** Farmers pay a smaller monthly fee in addition to a lower hourly rate.

As with the SunCulture model, each of these models is essentially an installment payment plan, and payments end once the farmer has paid in full for the equipment. However, the KickStart payment models use the PAYG technology to enable more flexible, fine-tuned payments in the pay-for-time-used and hybrid models, where the duration of financing may vary depending on how much the farmer uses the irrigation system.



## **Use Case 2: Rural-focused Commitment Savings to Cover Equipment Costs**

In areas where financing or PAYG approaches are not available for smallholder irrigation, the remaining option is for farmers to save up to purchase irrigation equipment. However, saving can be a challenge—in the absence of banks, farmers must rely on cash (which is easy to lose) or illiquid assets such as livestock. One possible solution is a layaway program allowing farmers to save up for a specific purpose.

Although urban-focused commitment savings schemes can potentially operate via smartphone apps, commitment savings for rural areas requires a low-tech user interface as far fewer customers have smartphones. Mali-based myAgro has developed a mobile layaway program for fertilizer and seeds, wherein farmers purchase scratch cards at their local store (valued at US\$0.50 to \$50), which are used to add funds to a layaway account in the same manner that the farmers would top up credit on their mobile phones. This approach could be potentially extended to purchase irrigation pumps.

In India, a national network of women's self-help groups capitalizes small revolving loan funds with their savings. Many of these groups in rural areas will pool resources to rent or purchase irrigation equipment. Fintech platforms for commitment savings could be used to streamline and formalize these arrangements.

## **Use Case 3: Credit Scoring for Farmers—Alternative Data and IoT Irrigation**

Whether for purchasing inputs, irrigation equipment, or other tools, lack of access to credit can limit the growth of farmers' businesses. Better credit data is one answer to this problem; however, credit scoring models may be tuned to the cash flows of market traders, workers, and so on who make up the bulk of the economy. Farmers' cash flows are fundamentally different, and analyzing a farm business can be complex because of differing crops, market prices, land sizes, climate fluctuations, and more; therefore, customized tools are useful to assess farmers' creditworthiness. However, many financial institutions do not have the in-house knowledge and resources necessary for this complex and potentially time-consuming analysis.

In Kenya, FarmDrive produces credit scores customized to the business of farming and connects farmers to lenders. It does this with a combination of data collected from the farmer via a mobile platform and alternative data sources such as social interactions, climate patterns, and economic data. Data is processed via machine-learning algorithms to build farmer credit scores and facilitate decisions by lenders, who can use the FarmDrive platform to disburse loans via M-Pesa mobile money. Farmers can use the FarmDrive platform to track their revenue, expenses, and crop yields, further enhancing the data available for scoring and potentially allowing for access to better credit terms.

Although access to credit facilitated by specialized scoring tools such as FarmDrive can enable farmers to purchase irrigation equipment, alternative data credit scoring is still in its infancy.

Data from Information of Technology (IoT)-enabled solar irrigation systems, including patterns of both irrigation and power offtake, could in the future improve the accuracy of credit scores and increase farmers' access to finance while driving behavioral analysis useful to lenders during loan repayment. These insights could be further enhanced through emerging technologies that leverage satellite imagery to monitor groundwater moisture.

#### **Use Case 4: PAYG Water for Irrigation**

Although increased access to irrigation benefits farmers, the resulting increased drawdown of groundwater can lead to water depletion. Therefore, a system of governance and incentives is necessary to ensure that all farmers benefit from groundwater resources. Fintech tools offer ways to streamline such systems and avoid overstressing water tables.

In Hebei Province, China, PAYG water for irrigation is managed by the government via a system that allocates water to farmers and then distributes it via smart meters, which measure discharge flows to the farmers' pumps and are topped up using integrated circuit (IC) cards (contactless smart cards much like those used by many cities' public transportation networks). Although some PAYG models are associated with shutoff mechanisms in solar-powered equipment, this model is implemented at the meter level and is, therefore, pumping technology-agnostic.

Water is allocated to farmers based on the size of their land and the crops they are producing. Usage rights are encoded onto the IC cards, and farmers receive advice on how to plan the usage of their allocation, which is prepaid when the farmers charge their IC cards up to the quota granted to them. If usage exceeds a certain rate, the system sounds an alarm to help the farmer avoid hitting the quota; when the farmer's allocation is exhausted, the meter will shut off the flow of water.

Before the system was implemented, groundwater was being overdrawn; in the new system, total water rights are calculated for the local area based on groundwater availability, and then individual farmer's usage rights are calculated as a percentage of the total water rights. At first, farmers protested the management of their water rights, but as the system ultimately produces a win-win situation by preventing the overdraw of groundwater, recent feedback from farmers has been positive.

#### **Potential Use Case 1: New Water Usage Management and Conservation Schemes**

Building upon the successful implementation of fintech tools for water resource management in China, additional fintech models can be applied in other regional contexts.

##### **Fintech Enhancement of Power Grid Feed-in for Solar Irrigation**

Although PAYG quota models work in areas such as Hebei where water is centrally controlled, elsewhere, usage depends on how farmers are incentivized. For example, Gujarat, India, has historically suffered from shortages of groundwater; today, solar pumps are

growing popular as the government provides subsidies for their purchase, and there is a fear that groundwater could be overdrawn because the pumps have minimal running costs.

One solution being piloted by the International Water Management Institute (IMWI) in Gujarat is to connect farmers' solar panels to the power grid, allowing them to sell excess energy as an alternative to running their solar pump for "free" irrigation. The result is that the farmer incurs an opportunity cost for running the irrigation pump and, therefore, will do so only to the level necessary to irrigate crops in an effort to optimize income from both farming and electricity generation.

In the IMWI pilot, the production and sale of electricity is tracked via a local cooperative, which sells the excess power to the utility in a single transaction and distributes the proceeds to farmers based on daily manual readings of the farmers' power meters. During the first two years of the pilot, farmers in the program used only 500 to 600 kilowatt hours of energy for irrigation each year; farmers without grid offtake connections typically used 1,000 kilowatt hours per year. This 40 percent to 50 percent reduction in energy usage roughly translates to an equivalent amount of water saved.

Although this program shows promise, there is a risk that farmers will simply pump more water and sell it to neighboring farmers—rather than feeding the energy back into the grid. Fintech tools could be applied to optimize and scale the program, standardizing and automating systems so that farmers could sell power directly to a utility with minimal overhead:

- Smart meters would track and report energy provided by the farmer to the power grid (to calculate payments to the farmer) and energy used for pumping (to assess water conservation), and a central smart meter would measure energy coming from farmers as a check on the accuracy of farmers' meters.
- Farmers would be able to track their energy production via short message service (SMS) or an app (depending on the local market) and would be compensated on a monthly basis via mobile money. A more advanced system could employ demand-based dynamic pricing with alerts from the power utility to the farmer (or even directly to an IoT solar irrigation pump), helping the farmer optimize revenue by generating electricity at higher-demand times of day and pumping water to an elevated tank at lower-demand times.
- A cloud-based software back end would coordinate all of the above, integrating with the power utility's systems for management, analytics, and accounting.

As a further step, this power grid feed-in program could be integrated with PAYG sales of solar pumps, such that a farmer could offset a portion of payments for the system by producing electricity or with a broader agricultural value chain marketplace platform as described in Potential Use Case 2: Marketplace Platforms with Irrigation Integration. Furthermore, the availability of power grid feed-in could improve the value proposition of solar irrigation, offsetting the additional cost of the elevated water tank associated with the technology, such that reliance on subsidies in markets such as India could be reduced.

Alternatively, farmers could sell excess power directly to their neighbors via a peer-to-peer microgrid within a village, with potential pricing and availability benefits for both power users and farmers. Bangladesh-based SOLshare is installing village microgrids that integrate local electricity trading, mobile money payment, and data analytics for grid management. The microgrid can then connect to and trade with the national power grid to balance power usage needs and solve the “last mile” distribution problem for utilities.

### Managing Water Pricing and Usage with Blockchain Tools

Although still largely in the conceptual stage, blockchain tools provide decentralization, transparency, and efficiency, providing a foundation for new ways of managing agricultural water resources that would previously have been infeasible.

**Optimizing water pricing and usage:** Irrigation flow meters across a given groundwater recharge area could report transaction data to a blockchain, which would store a public, immutable record of water usage in the area. The blockchain data could then be analyzed using artificial intelligence to manage pricing incentives (via PAYG technology) and optimize water usage and productivity across the area (Lin et al. 2018). Such a system could build upon PAYG water resource management as implemented in areas with a water authority such as the Hebei, China, example mentioned previously.

**Managing water rights:** Water rights markets are mature in some countries, such as Australia and the United States, but they can be complicated and lack transparency. Blockchain is under consideration to streamline these markets, providing an open and transparent record of ownership that can help remove middlemen and prevent fraud. Water distribution resulting from trades could be managed by IoT flow sensors. Such applications could be transferable to emerging markets, potentially opening up the opportunity to “leapfrog” past traditional water rights trading and implement “trustless” blockchain solutions that minimize the need for bureaucratic overhead. For example, Fremantle, Australia, is rolling out a “smart city” initiative that includes a partnership with Power Ledger to manage water and power assets. The Power Ledger platform will provide a transaction layer for energy and water systems, which will allow for peer-to-peer trading of energy and water assets.

### Potential Use Case 2: Marketplace Platforms with Irrigation Integration

Irrigation is one input in a series of systems, cash flows, and risk management that farmers contend with on a day-to-day basis, so agricultural financing is most useful to farmers if it considers the entirety of the system rather than just one part. Therefore, lenders need to consider the value chain surrounding the farmer’s business, from inputs to offtake. The goal of agricultural value chain financing is to reduce the risk associated with production and increase the willingness of financial institutions to lend, as well as the willingness of farmers to participate in that value chain.

Fintech tools that consider the entire system are likely to be most useful to farmers; marketplace platforms designed to support agricultural value chains are a promising possibility to bring together farmers, input suppliers, wholesale buyers, transporters, financial services providers, and agricultural training organizations. With suitable low-cost fintech tools running under a sustainable fee-for-service model, such platforms could both facilitate greater access to irrigation as well as use IoT-enabled solar irrigation systems as a cornerstone of credit scoring, contract enforcement, and water resource management.

Rural-focused marketplace platforms that facilitate trading in agricultural products are starting to emerge under a variety of business models, though they generally address just a portion of the agriculture value chain and, to date, the greatest extent of irrigation data integration is to track whether a farmer utilizes irrigation or not.

A robust marketplace platform could lower transaction costs and enable scale to the point where multiple, diversified agricultural value chains could operate on the platform. For example, Alibaba's Taobao e-commerce marketplace platform launched its Rural Taobao initiative to extend its reach to all of China; villages with clusters of online entrepreneurs are known as "Taobao villages." As penetration of the platform increases in a given region, the variety of products traded increases, and wholesale ventures start to grow alongside retail. Although the platform is not agriculture-focused, in some cases, it is used to sell produce to urban customers. Taobao provides sales analytics to its marketplace sellers, which can enable sellers, including farmers, to predict demand for their products. Rural Taobao has established more than 30,000 rural service centers and aims to reach 150,000 villages by 2021.

Bloom is a social enterprise running an agriculture-focused platform, using climate and market analytics to advise farmers on what to grow, and then providing a marketplace for seeds and other inputs in addition to financing and access to markets to sell their crops. Through its subsidiaries and network of local franchisees, the company has reached more than 100,000 farmers in Asia and Latin America.

In addition to the tools provided by companies such as Taobao and Bloom, an agricultural marketplace platform could help farmers manage water resources while utilizing irrigation data to help understand farmers' businesses and provide advice and loans. The platform could bring the following benefits, with irrigation systems driving much of the activity on the platform:

1. **Access to finance**, including loans, insurance, and forward contracts that set fixed prices for crops, thereby facilitating lending. As in Use Case 4 (PAYG Water for Irrigation), irrigation data could be a key aspect of credit scoring as well as behavioral analysis to help manage loan repayment. Data collected on farmers' cash flows would allow banks to better fit their products to farmers' needs.
2. **Access to information** including marketplace and climate trends, as well as advice on staggered planting and sales schedules that match market demand and help the farmer maintain liquidity.

3. **Water resource management** via customized alerts on when it is best to water crops based on climate data and what time of day power offtake prices are higher, making solar electricity generation a favorable alternative to pumping water, as in Potential Use Case 1 (Credit Scoring for Farmers—Alternative Data and IoT Irrigation); power generated could be applied directly to loan repayment.
4. **Increased transparency** with detailed tracking of value chain cash flows, electronic warehouse receipts, and so on.

Farmers on the platform would gain credibility with buyers and lenders; similarly, farmers would be attracted to the platform by the better credit and business terms available. The platform would facilitate transactions and enforce contracts such as

- Forward contracts ensuring price stability for farmer, lender, and buyer;
- Automatic loan repayment upon offtake;
- Insurance payout (and loan repayment) as triggered by climatic conditions;
- Shutoff of PAYG solar irrigation pumps (Use Case 1: PAYG Shutoff Models to Reduce Up-Front Equipment Cost) and other equipment to enforce contract compliance; and
- Collateralization of paid-off irrigation and other equipment so as to facilitate lower-cost credit.

While the platform would offer considerable benefits, the enforcement mechanisms would help reduce risk. Two major concerns could be addressed by enforcement via irrigation pump shutoff:

1. **Side-selling:** Although forward contracts may be used to stabilize prices and make financing possible, farmers may be tempted to side-sell following a spike in prices, reneging on agreements to get a better price. To counter this, the solar irrigation system would shut down in the absence of delivery to the buyer at the contracted price (or an insurance payout). The buyer would have discretion to relax the contract terms depending on circumstances.
2. **Loan delinquency:** Although much of the repayment for each loan is likely to be paid via proceeds from the farmer delivering the crop to the buyer, often farmers have non-harvest cash flows as well and, in those cases, prefer loan products that have regular payments. To help maintain repayment discipline throughout the loan, a smart contract tied to the loan could enforce irrigation shutoff in case of significant delinquency, though the lender would have discretion to relax the terms.

Although these mechanisms would not be feasible in cases where farmers owned their irrigation systems outright, contracts could still be written such that farmers' ability to sell power back to the grid could be curtailed in case of breach of contract (or simply desubsidized in areas with an offtake subsidy). Furthermore, by the time farmers achieved

ownership via a PAYG plan, they would typically be familiar with the benefits of the platform including access to markets and finance.

By capturing transaction and operational data along the value chain, including data from IoT-enabled solar irrigation systems, the platform operator could better understand pain points and adjust service offerings accordingly. Furthermore, with sufficiently sophisticated data and monitoring enabled by the platform, lenders could move from providing term loans to flexible lines of credit that rapidly respond to positive or negative signals in the farmer's business by increasing or decreasing access to credit. As the quality and quantity of data collected from irrigation and related systems improves, new products and services are likely to become possible.



## The Way Forward

Although global access to water, sanitation, and irrigation is increasing, without increased financial inclusion, many will continue to be left out. Financial technology (fintech) tools can enhance the effectiveness of financial inclusion for water, and this is already happening in some places, as demonstrated in several of the use cases.

Much space exists to further build on these use cases, with the potential use cases as a starting point; as costs continue to fall and technologies mature, new uses cases are likely to emerge. In particular, the increasing accessibility of smartphones for the poor will continue to open up new possibilities, transforming the financial options available in the developing world.

As new fintech tools are developed, they can readily be adapted to fit the water sector. However, taking advantage of fintech for water requires a coordinated effort between the public and private sectors.

**Governments** can ensure that the regulatory and policy environment encourages the application of fintech—for example, through creation of regulatory sandboxes that allow for experimentation at smaller scale before broader rollout in a more regulated environment and the implementation of infrastructure that benefits all financial institutions, such as payments networks, standard national digital identity, and e-KYC (know your customer) frameworks. In some cases, fintech solutions such as credit bureaus or marketplace platforms may be subsidized at first, with the goal of profitable operation.

In all cases, governments need to maintain a balance between spurring innovation and maintaining the integrity of the financial system—avoiding over-regulation while also looking out for the interests of consumers. Sensible consumer protection laws and financial literacy programs are helpful for customers to benefit from financial services, whether fintech or otherwise; financial literacy programs lend themselves to public provision as private actors do not have the proper incentives. Finally, in considering potential fintech solutions, keep in mind that access to water can easily spark social tension—this is a sector that requires good oversight and clear regulation.

**Donor agencies** can support the development of policies that encourage the growth of fintech, particularly by encouraging cross-sector collaboration between governments and fintech experts. Next, they can provide seed-stage and scale-up funding for social enterprises combining fintech and water, generating proof of concept that can spur further investment. In markets that lack a credit bureau, or where the scope of the credit bureau is limited, donors should provide a subsidy to ensure that credit histories are generated for the poor; subsidizing a credit bureau may be catalytic in that it prompts responsible behavior and attracts private sector providers. Finally, donors can play a key role in knowledge-sharing between fintech players and the water sector, as related technologies are evolving rapidly; for example, much of this paper will be outdated in just a few years' time.

**Utilities** have an unprecedented opportunity to take advantage of the variety of fintech tools highlighted to improve efficiency and lower costs. Small providers can professionalize



operations and take advantage of utility-in-a-box-type solutions to gain access to credit and larger business opportunities.

**Fintech companies and financial institutions** stand to benefit from business opportunities they can unlock by familiarizing themselves with the water sector and developing products and services that help more of their customers gain access. With outdated systems and substantial challenges across the water sector, it is ripe for disruption; some of the use cases in this paper can serve as initial ideas.

Within urban water and sanitation and smallholder irrigation, there are specific actions that some governments, regulators, and donor agencies can take to further financial inclusion.

## Policy Recommendations—Water and Sanitation for Urban Households

### Governments and Regulators

- *Explore how fintech can support hybrid solutions to service provision* (such as citywide inclusive sanitation) that combine centralized infrastructure such as sewers and irrigation canals with innovative off-grid solutions.
- *Demand standardized, interoperable technologies from vendors*—reduction and elimination of proprietary technology will increase competition and lower costs. Areas to note include interoperable pay-as-you-go (PAYG) shutoff technology and water metering and open application programming interfaces (APIs) to allow for data sharing between devices and systems so that third parties can build upon existing infrastructure and data to add new services.
- *Consider “smart subsidies” that target the poorest*, whether through increasing block tariffs or more finely tuned subsidy schemes that aim to meet the needs and ability to pay of all citizens or broader rollout of prepaid standpipes with cross-subsidization by higher-income households.
- *Mandate public utilities to report to credit bureaus* and incentivize small and private utilities to report as well.

### Donor Agencies

- *Ensure that infrastructure investments leverage fintech*—for example, by supporting utilities to improve billing processes and explore applications of PAYG water to increase the reach of their networks.
- *Help governments develop subsidies* such that they are progressive in their expansion of access to water and sanitation.

## Policy Recommendations—Smallholder Irrigation

### Governments and Regulators

- *Encourage the credit bureau to capture data for credit scoring of farmers*, which may require bringing in outside expertise.

- *Consider incentive schemes that foster responsible use of water resources—for example, subsidizing connections to power grid feed-in for farmers using solar irrigation.*
- *Provide tax incentives for marketplace facilitation platforms—this may be revenue-neutral because the platforms can, in turn, increase business activity as well as transparency and tax collection rates.*

### Donor Agencies

- *Support the rollout of marketplace facilitation platforms with the goal of sustainable fee-for-service operation. Because these are complex systems with multiple players, support research and development to understand potential users' needs and to build appropriate solutions.*
- *Promote the development of open data standards and APIs for IoT irrigation equipment to lower integration costs and facilitate the introduction of new services.*

## Appendix A: Organizations Mentioned

Organization	Website
AirtelTigo	<a href="http://www.airteltigo.com.gh">www.airteltigo.com.gh</a>
Alibaba	<a href="http://www.alibaba.com">www.alibaba.com</a>
Amazon Marketplace	<a href="http://www.amazon.com">www.amazon.com</a>
Ant Financial	<a href="http://www.antfin.com">www.antfin.com</a>
APPSANI	<a href="http://appsani.weebly.com/sejarah-appsani.html">appsani.weebly.com/sejarah-appsani.html</a>
ASA	<a href="http://www.asa.org.bd">www.asa.org.bd</a>
Bloom	<a href="http://bloom.farm">bloom.farm</a>
BRAC	<a href="http://www.brac.net">www.brac.net</a>
CGAP	<a href="http://www.cgap.org">www.cgap.org</a>
Credit Karma	<a href="http://www.creditkarma.com">www.creditkarma.com</a>
E-Power Cambodia	<a href="http://www.e-power.com.kh">www.e-power.com.kh</a>
eWaterPay	<a href="http://www.ewaterpay.com">www.ewaterpay.com</a>
FarmDrive	<a href="http://www.farmdrive.co.ke">www.farmdrive.co.ke</a>
Grundfos	<a href="http://www.grundfos.com">www.grundfos.com</a>
International Water Management Institute	<a href="http://www.iwmi.cgiar.org">www.iwmi.cgiar.org</a>
KickStart	<a href="http://www.kickstart.org">www.kickstart.org</a>
LifeStraw	<a href="http://www.lifestraw.com">www.lifestraw.com</a>
Loowatt	<a href="http://www.loowatt.com">www.loowatt.com</a>
Mambu	<a href="http://www.mambu.com">www.mambu.com</a>
M-KOPA	<a href="http://www.m-kopa.com">www.m-kopa.com</a>
M-Pesa	<a href="http://www.vodafone.com/content/index/what/m-pesa.html">www.vodafone.com/content/index/what/m-pesa.html</a>
myAgro	<a href="http://www.myagro.org">www.myagro.org</a>
Oradian	<a href="http://www.oradian.com">www.oradian.com</a>
Paygee	<a href="http://www.paygee.com">www.paygee.com</a>
Power Ledger	<a href="http://www.powerledger.io">www.powerledger.io</a>
Revolut	<a href="http://www.revolut.com">www.revolut.com</a>
Safe Water Network	<a href="http://www.safewaternetwork.org">www.safewaternetwork.org</a>
Sanergy	<a href="http://www.sanergy.com">www.sanergy.com</a>
Sarvajal	<a href="http://www.sarvajal.com">www.sarvajal.com</a>
Sentinel Chain	<a href="http://www.sentinel-chain.org">www.sentinel-chain.org</a>
SOLshare	<a href="http://www.me-solshare.com">www.me-solshare.com</a>
Stripe	<a href="http://www.stripe.com">www.stripe.com</a>
SunCulture	<a href="http://www.sunculture.com">www.sunculture.com</a>
Taobao	<a href="http://www.taobao.com">www.taobao.com</a>
Tez / Google Pay	<a href="http://tez.google.com">tez.google.com</a>
Timo	<a href="http://www.timo.vn">www.timo.vn</a>
TransferWise	<a href="http://www.transferwise.com">www.transferwise.com</a>
Venmo	<a href="http://www.venmo.com">www.venmo.com</a>
VisionFund Cambodia / Woori Bank	<a href="http://www.woorifinanc cambodia.com">www.woorifinanc cambodia.com</a>
Water.org	<a href="http://www.water.org">www.water.org</a>
WeChat	<a href="http://www.wechat.com">www.wechat.com</a>
XacBank	<a href="http://www.xacbank.mn">www.xacbank.mn</a>

## References

- Banco Internacional del Perú. 2018. “House Savings Accounts with Outside Support.” <https://interbank.pe/ahorro-casa-con-apoyo-del-exterior>.
- Collins, Daryl, Jonathan Morduch, Stuart Rutherford, and Orlando Ruthven. 2009. *Portfolios of the Poor*. Princeton, NJ: Princeton University Press.
- Department for International Development. 2006. *Charging to Enter the Water Shop*. United Kingdom: Cranfield University.
- GSMA. 2017. “Sanergy: Exploring the Use of Mobile Enabled Sensors to Optimize Sanitation Waste Collection in Kenya.” [gsmaintelligence.com](https://gsmaintelligence.com).
- . 2018. *The Mobile Economy 2018*. London, UK: GSMA Intelligence.
- Heymans, Christiaan, Kathy Eales, and Richard Franceys. 2014. “The Limits and Possibilities of Prepaid Water in Urban Africa: Lessons from the Field.” World Bank, Washington, DC.
- Innovations for Poverty Action. 2005. “Finding Missing Markets: An Agricultural Brokerage Intervention in Kenya.” New Haven, CT: Innovations for Poverty Action.
- International Finance Corporation. 2018. “Impact of Efficient Irrigation Technology on Small Farmers.” World Bank, Washington, DC.
- International Housing Coalition. 2018. “Key Policy Topics: Urban Water and Sanitation.” IHC Global, Washington, DC.
- Kingdom, Bill, Roland Liemberger, and Philippe Marin. 2006. “The Challenge of Reducing Non-Revenue Water in Developing Countries.” The Water Supply and Sanitation Sector Board Discussion Paper Series No. 8. World Bank, Washington, DC.
- KlickEx Pacific. 2012. “Digicel Mobile Money Expands to Include Schools Fees in Tonga.” <https://www.klickexpacific.com/news.aspx>.
- Lin, Yu-Pin, Joy R. Petway, Wan-Yu Lien, and Josef Settele. 2018. “Blockchain with Artificial Intelligence to Efficiently Manage Water Use under Climate Change.” *Environments* 5 (3): 34. <https://doi.org/10.3390/environments5030034>.
- Melo, Jose Carlos. 2005. “The Experience of Condominium Water and Sewerage Systems in Brazil: Case Studies from Brasilia, Salvador and Parauapebas.” World Bank, Washington, DC.
- My Smart Price. 2018. “Jio Phone Price in India.” <https://www.mysmartprice.com/mobile/jio-phone-msp13034>
- O'Connor, Greg. 2014. “Moore’s Law Gives Way to Bezos’s Law.” <https://gigaom.com/2014/04/19/moores-law-gives-way-to-bezoss-law/>.
- Steel, William. 2018. “Challenges to Financing Toilets in Ghana.” GAMA Urban Sanitation Workshop. Accra, Ghana.
- Toilet Board Coalition. 2016. *The Digitization of Sanitation*. Geneva, Switzerland: The Toilet Board Coalition.
- Voltornist, Andrey. 2014. “Mobile Broadband Reach Expanding Globally.” [gsmaintelligence.com](https://gsmaintelligence.com).
- Waldron, Daniel, Sandy Hwang, and Charles Yeboah. 2018. “Pay-as-You-Drink: Digital Finance and Smart Water Service.” *Consultative Group to Assist the Poor*. Washington, DC.
- Winpenny, James, Sophie Trémolet, Rachel Cardone, Joel Evan Kolker, Bill Kingdom, and Lyndsay Mountford. 2016. “Aid Flows to the Water Sector.” World Bank, Washington, DC.
- World Bank. 2017. “Understanding Poverty: Sanitation.” Washington, DC: World Bank Group.
- . 2018. “WASH Poverty Diagnostic – Key Facts in 18 Countries.” World Bank, Washington, DC.
- Xie, Hua, Liangzhi You, Benjamin Wielgosz, and Claudia Ringler. 2013. “Estimating the Potential for Expanding Smallholder Irrigation in Sub-Saharan Africa.” *Agricultural Water Management* 13: 183–93. doi:10.1016/j.agwat.2013.08.011.
- Xinhua. 2018. “China’s Mobile Payment Volume Tops 81 Trillion Yuan.” <http://www.chinadaily.com.cn/a/201802/19/WS5a8a8e42a3106e7dcc13d08f.html>.

