The Role of Digital Identification in Agriculture

Emerging Applications

WORLD BANK GROUP

ID4D
IDENTIFICATION FOR DEVELOPMENT

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About ID4D

The World Bank Group's Identification for Development (ID4D) initiative uses global knowledge and expertise across sectors to help countries realize the transformational potential of digital identification systems to achieve the Sustainable Development Goals (SDGs). It operates across the World Bank Group with global practices and units working on digital development, social protection, health, financial inclusion, governance, gender, and legal, among others.

The mission of ID4D is to enable all people to access services and exercise their rights by increasing the number of people who have an official form of identification. ID4D makes this happen through its three pillars of work: thought leadership and analytics to generate evidence and fill knowledge gaps; global platforms and convening to amplify good practices, collaborate, and raise awareness; and country and regional engagement to provide financial and technical assistance for the implementation of robust, inclusive, and responsible digital identification systems that are integrated with civil registration.

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To learn more about ID4D, visit id4d.worldbank.org

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Abbreviations

CDD	Customer Due Diligence
CGAP	Consultative Group to Assist the Poor
eID	Electronic Identification
FAMA	Federal Agricultural Marketing Authority
FI	Financial institutions
FISP	Fertilizer Input Subsidy Program
GDP	Gross Domestic Product
GES	Growth Enhancement Scheme
GoI	Government of India
GSMA	Global System for Mobile Communications
ID	Identification
IVR	Interactive Voice Response
KYC	Know-Your-Customer
MNO	Mobile Network Operator
NID	National Identification
OTP	One-Time Password
PDS	Public Distribution System
SDG	Sustainable Development Goal
SIM	Subscriber Identity Module
UIDAI	Unique Identification Authority of India
UIN	Unique identification number
USD	United States Dollar
USSD	Unstructured Supplementary Service Data

Executive Summary

Agricultural development is one of the most powerful tools to end extreme poverty. Agriculture accounts for nearly one-third of global gross domestic product (GDP), and the majority of the world's poor live in rural areas and make a living through agriculture. To end extreme poverty by 2030, most of the income gains will need to be made in rural areas, including by boosting smallholder farmers' earnings from farming and off-farm activities.[1] Increasing the ability of such smallholders to professionalize, improve their productivity, and generate additional income is therefore critical to both alleviate rural poverty and increase food security.

Smallholder families have complex livelihoods. They typically rely on income from a variety of sources, including government safety nets, subsidies, and off-farm enterprises. Enabling these families to exit poverty will require innovative solutions to address critical challenges, such as (1) lack of access to financial services, (2) lack of adequate supply-chain traceability, (3) challenges related to the delivery of goods and services, and (4) gender inequality. When smallholder farmers lack government recognized identification (ID) documents, these and other challenges are further exacerbated. Without an official proof of identity, many smallholder farmers struggle to access services and subsidies and to seize new opportunities offered by innovations in mobile technologies, finance, and beyond.

A robust, government recognized ID can help smallholder farmers formally register land and livestock, and access mobile, financial, and other services that would allow them to work, sell, and spend income formally. Thus, identification is an important building block to achieving Sustainable Development Goal #2: *End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.*

This paper looks at three key applications of identification in agriculture to understand how these can help tackle some of the critical challenges, remove barriers to agricultural productivity, and enhance farmers' livelihoods, including through: (1) increasing the effectiveness and inclusivity of subsidy programs; (2) enabling formal land and asset registration; and (3) improving data about farmers' economic activity and needs. See Table 1.

At the same time, there are challenges to maximizing the benefits of identification in agriculture. ID systems increasingly rely on digital infrastructures for authentication and identity verification. Although mobile and broadband coverage is growing at a rapid rate worldwide, rural areas often still lack the reliable mobile and Internet connectivity required for certain applications of digital IDs. Rural households are also less likely to have the digital literacy required to navigate digital ID systems and may be less able to monitor and hold authorities accountable for how their personal data are being used and shared. Therefore, any ID application in agriculture will need to consider how data protection and privacy safeguards may need to be adapted to rural contexts.

In addition, ID applications in agriculture may face institutional arrangements and coordination challenges. In the presence of a foundational ID system, the Ministry of Agriculture or other implementer will need to coordinate with other areas of the government, including the ID provider. In the absence of a foundational ID system, the Ministry of Agriculture or other implementer will need to consider how they can meet their own needs while coordinating with other agencies and partners who may be implementing separate yet overlapping functional ID systems.

1 The World Bank Agriculture Overview, http://www.worldbank.org/en/topic/agriculture/overview

Table 1. Identification Applications in Agriculture

Applications	How identification helps address barriers	Case studies included in this paper
1. Subsidy distribution	▪ Acting as ***a bridge to financial services*** ▪ Improving the efficiency of the ***delivery of goods*** and services through the reduction of fraud and "ghost recipients" ▪ Helping to ensure that women have equal access to subsidies	Estonia India Nigeria[2]
2. Land and asset registration	▪ Supporting ***access to financial services*** by increasing visibility on farmer collateral and creditworthiness ▪ Improving ***supply-chain traceability*** by linking farmers to assets ▪ ***Enabling women*** to demonstrate individual ownership of assets	Estonia Uruguay Malaysia
3. Unique, data-driven farmer profiles	▪ Supporting ***access to financial services*** by increasing visibility on farmer economic activity and creditworthiness ▪ Improving ***supply-chain traceability*** by digitizing necessary information ▪ Improving ***delivery of goods and services*** by increasing visibility on farmers' location and information needs ▪ ***Enabling women*** to equally demonstrate economic activity when necessary to access goods and services	India Sri Lanka Thailand Malaysia

It should be noted that practical examples of agriculture-related ID applications are still limited, and many existing applications are at a nascent stage. Much additional research, piloting, and rigorous impact evaluations are needed to improve our understanding of the opportunities and challenges for leveraging digital identification in agriculture.

2 This case study will analyze one specific pilot of a functional ID system for agriculture. While not foundational, it will help in understanding some of the challenges with IDs for agriculture, and in showing some of the benefits that foundational systems may provide over functional systems.

1. Introduction

Why ID for Agriculture?

Agricultural development is one of the most powerful tools to end extreme poverty. Agriculture accounts for nearly one-third of global gross domestic product (GDP). Growth in the agriculture sector is two to four times more effective in raising incomes among the poorest compared to other sectors.[3]

Most of the world's poor live in rural areas, and a majority of poor working adults make a living through agriculture. Therefore, most of the income gains needed to end poverty by 2030 will need to come from rural areas, including by boosting smallholder farmers' earnings from farming and off-farm activities, such as processing and services.[4] Smallholder farmers typically own two hectares of land or less, and many of them do not produce enough to sell produce for income, relying instead on subsistence farming to support their household. Increasing the ability of such smallholders to professionalize, enhance their productivity, and generate additional income will be critical to alleviate rural poverty and increase food security.

Smallholder families have complex livelihoods. They typically rely on income from a variety of sources, including government safety nets and other nonagricultural sources, such as labor and off-farm enterprises. In developing countries, smallholder farmers are among the groups that are most likely to struggle to access appropriate financial services, secure property rights, secure equal education and economic opportunities for women, and have the resources and information necessary to access urban and export markets to increase their income.[5] Lifting smallholder families out of poverty, therefore, will require solutions that address the complexities of these needs.

When smallholder farmers lack government recognized identity documents, the barriers they face in accessing services and opportunities are further exacerbated. There are an estimated 1 billion people globally without an official proof of identity,[6] and the rural poor—many of whom are smallholder farmers—are among the groups most likely to lack official identity documents.[7] Rural women, who account for an average of 43 percent of the agricultural workforce in developing countries,[8] are particularly likely to lack access to identification.

A robust, government recognized ID can help smallholder farmers formally register land and livestock, and access mobile, financial, and other services that allow them to work, sell, and spend income formally. Thus, identification is an important building block to achieving Sustainable Development Goal #2: *End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.*

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3 Townsend, Robert. 2015. *Ending poverty and hunger by 2030: an agenda for the global food system,* World Bank Group. http://documents.worldbank.org/curated/en/700061468334490682/Ending-poverty-and-hunger-by-2030-an-agenda-for-the-global-food-system

4 World Bank. 2018c. The World Bank Agriculture Overview, http://www.worldbank.org/en/topic/agriculture/overview

5 This is a non-exhaustive list of challenges facing smallholder farmers in developing countries, generally, as these challenges relate to the rest of this paper. This is not to imply that all smallholders face the same challenges, as clearly context matters and challenges will vary based on country, crop, climate, and many other factors.

6 World Bank. 2018a. "The World Bank ID4D 2018 Global Dataset," http://id4d.worldbank.org/global-dataset

7 ID4D Strategic Roadmap, http://pubdocs.worldbank.org/en/179901454620206363/Jan-2016-ID4D-Strategic-Roadmap.pdf

8 FAO. 2012. "Smallholders and Family Farmers," http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet_SMALLHOLDERS.pdf

The Goal of This Paper

This paper summarizes current knowledge of the role of digital *foundational ID* systems—i.e., those that provide general purpose identification (see Box 1)—in improving agricultural outcomes. Functional ID systems, created with a single purpose or use in mind, may be used to administer programs for smallholder farmers and enable access to certain transactions and services, including off-farm employment, health, and education. However, functional ID systems tend to be costly to operate, often place an added administrative and cost burden on rural households trying to access a variety of services, and can limit opportunities for data sharing across sectors. This paper will also focus on digitally enabled ID systems.

See Box 1 for more complete definitions of these and other ID-related terms.

Box 1: Definitions: Foundational, Functional, and Digital ID systems

There are two broad categories of ID systems: *foundational* systems that are built with the objective of providing general identification for a wide variety of purposes (examples include population registries, unique identification numbers (UINs) and national ID (NID) cards); and *functional* systems that provide IDs for a specific sector or purpose, such as voter IDs, IDs that facilitate access to health records, or tax IDs.

Both foundational and functional ID systems can be either paper based or digital. Paper-based systems are rapidly giving way to systems involving the use of digital databases and digital biometric technology for registration, authentication, data transfer, and storage, even in poor countries. Digital foundational ID systems can enable a variety of government and private sector service providers to authenticate individuals using the same identity platform. Foundational and functional ID systems can coexist within the same country: for example, if a country has a robust, digital foundational ID system, a service provider (such as a bank) could still choose to create a bank-specific functional identity linked to a bank-issued credential or a biometric.

This paper focuses on foundational digital identification systems, unless otherwise noted. The term *national* ID system is also used and refers to a specific type of foundational system that provides national IDs (NIDs). In many countries, national ID systems are used by the government primarily to establish and provide recognition and proof of citizenship.

This paper includes case studies from select countries to better understand how foundational ID systems are currently being used to improve agriculture, and to synthesize early lessons for leveraging ID systems to address the unique challenges of serving smallholder farmers. However, it should be recognized that the use of foundational ID systems in agriculture has been limited compared to other sectors. For example, a 2016 assessment by the International Telecommunication Union (ITU) found that, among 43 countries, only Nigeria and Thailand (at the time) had applied their national ID system to agricultural functions.[9]

We hope that this initial effort to gather examples of emerging uses of leveraging foundational ID in agriculture will lead to further research and policy discussions to expand our understanding of how foundational ID systems can improve agricultural outcomes, make service delivery more efficient, and support the Sustainable Development Agenda, including to end poverty by 2030.

9 ITU. May 2016. "Review of National Identity Programs," page 39 https://www.itu.int/en/ITU-T/focusgroups/dfs/Documents/09_2016/Review%20of%20National%20Identity%20Programs.pdf. Note that the Thailand program with SmartIDs for farmers started in 2013 but was discontinued when the national administration changed, as confirmed through an interview with Dr. Kamolrat Intaratat, Chair of the Asia Pacific Telecentre Network and Associate Professor at Sukhothai Thammathirat Open University.

2. Relevant Challenges

The challenges that smallholder farmers face are complex and vary greatly across different countries and by type of farmer.[10] For instance, smallholder farmers often struggle to access appropriate financial services, secure their property rights, secure equal education and economic opportunities for women, and have the information and digital literacy necessary to access urban and export markets to increase their incomes.[11]

Identification cannot solve all of these challenges but can be a first step toward overcoming some critical barriers to achieve better development outcomes for smallholder farmers. In particular, inclusive, robust, and responsible digital ID systems can help smallholders overcome some of the barriers they face by (1) increasing access to financial services, (2) increasing supply-chain traceability, (3) improving the delivery of goods and services, and (4) empowering women. The needs in each of these four areas are outlined below.

Lack of Access to Financial Services

Access to financial services and a wide range of financial products, including credit, savings, and insurance is critical for smallholder farmers, as they allow them to professionalize and grow their business. However, lack of official identification presents a barrier for many farmers. As of 2016, informal and formal credit to smallholder farmers amounted to only 50 billion USD, compared to the over 270 billion USD required by smallholders in Latin America, Sub-Saharan Africa, and South and Southeast Asia to grow their businesses and improve their livelihoods. Agricultural insurance reached just 10 percent of smallholders, and fewer than 15 percent had access to a formal savings account.[12] While the reasons for these gaps are complex, the lack of formal identification is a clear barrier to access formal financial services.

The vast majority of financial institutions (FIs), including both banks and mobile money providers, require an official ID in order to open an account as part of their compliance with know-your-customer (KYC) and customer due diligence (CDD) requirements.[13] While some countries and FIs allow for flexibility in these requirements, that is for low-value accounts intended only to store and send money, a government-issued, foundational ID is nearly always required to access credit, crop insurance, and higher value accounts for farmers as their productivity and income levels increase.

Lack of Supply-Chain Traceability

There is growing global interest in agricultural supply-chain traceability and transparency to ensure food safety and access new markets. Whether smallholder farmers are selling produce locally, regionally, or globally, they will increasingly be asked to disclose the origin of their produce, especially when attempting

10 A full description of the challenges facing smallholder farmers is not in the scope of this paper.
11 This is a non-exhaustive list of challenges facing smallholder farmers in developing countries, generally, as these challenges relate to the rest of this paper. This is not to imply that all smallholders face the same challenges, as clearly context matters and challenges will vary based on country, crop, climate, and many other factors.
12 Dalberg. 2016. "Inflection Point: Unlocking growth in the era of farmer finance," Rural and Agricultural Finance Learning Lab, April. https://www.raflearning.org/post/inflection-point-unlocking-growth-era-farmer-finance
13 World Bank. 2018. G20 Digital Identity Onboarding. https://www.gpfi.org/sites/default/files/documents/G20_Digital_Identity_Onboarding_WBG_OECD.pdf

to enter larger markets. This is due both to customers' growing demand for ethical and organic produce, and the need to quickly trace any disease outbreak that originates in the food supply. This level of traceability relies on the ability to track produce back to a single farm of origin. In the case of smallholder farmers, this often means tracing back to a single farmer, which can be greatly supported by the use of a unique ID. In addition, IDs can help better integrate and connect the types of data necessary to gain visibility of the agricultural supply chain, as demonstrated by the case study from Malaysia and research from Sri Lanka.

Inefficient Delivery of Goods and Services

Private and public sector service providers often struggle to deliver goods and services to rural areas where smallholder farmers are located. In part, this is due to infrastructure challenges such as the lack of quality roads. However, service providers also often lack data regarding where farmers are and what goods and services they need. For example, in order to provide farmers with targeted extension services and more efficient subsidy allocation, it is vital to identify farmers and have accurate data on farm size, the types of crops being grown, and other relevant information. A robust foundational ID system can uniquely identify farmers and support accurate land registration, which can in turn facilitate the effective and inclusive delivery of services and other support for farmers by allowing service providers to better identify and locate smallholder farmers and design programs more closely targeted to their needs. Digitizing subsidies and linking their disbursement to a foundational ID helps minimize leakages[14] and ensure that farmers receive the appropriate amount and type of support they need.

Disadvantages Faced by Female Farmers

If women farmers were to have the same access to productive resources as men, they could increase yields on their farms by 20–30 percent, lifting an estimated 100–150 million people out of hunger.[15] Yet, the recent Smallholder Financial Diaries conducted by the Consultative Group to Assist the Poor (CGAP) found that as smallholder farmers' incomes increased, differences in wealth between men and women actually widened, signaling a clear need for tailored strategies to support female smallholder farmers.[16] Foundational ID systems that are inclusive and strive for universal coverage can help to ensure that women are not unintentionally left out of assistance programs due to lack of identification. In addition, foundational IDs ensure that women can participate equally in social, political, and economic life. For example, providing women with a foundational ID is a first step in enabling women to register for their own SIM card, so that they can have their own mobile phone and their own mobile money wallet (or other type of financial account).

14 World Bank. 2018b. *Public Sector Savings and Revenue from Identification Systems: Opportunities and Constraints.* http://pubdocs.worldbank.org/en/745871522848339938/PublicSectorSavingsandRevenueIDSystems-Web.pdf
15 FAO. 2012. "Smallholders and Family Farmers."
16 Interview, CGAP Smallholder Team, May 24, 2018.

3. Role of Foundational IDs

To understand how foundational ID systems can increase the productivity of smallholder farmers and overcome the challenges described in Section 2, this section will use case studies from countries that have tried—with varying degrees of success—to leverage foundational IDs to deliver agricultural subsidies, enable the registration of assets, and create and use unique farmer profiles for data-driven decision making and targeted support.

It should be noted that practical examples of applications are still few, and many existing applications are at a nascent stage. This discussion presents early learnings, which hopefully will inspire additional research, piloting, and carefully documented and evaluated implementation of programs to increase collective understanding of the opportunities and challenges for leveraging foundational ID systems for better development outcomes in agriculture.

Subsidy Distribution

Subsidies play a key role in agriculture in both high- and low-income countries.[17] Broadly speaking, smallholder farmers' incomes can vary greatly based on external factors beyond their control, including weather patterns, the spread of plant and animal diseases, natural disasters, global price shocks, and innovations in (agricultural) technology. As a result, governments often choose to use subsidies to support smallholder livelihoods and provide a safety net for farmers. Agricultural subsidies are often intended for specific inputs, especially fertilizers and seeds. Food may also be distributed at subsidized prices (or even for free) in the case of drought or natural disasters that render farmers unable to grow or buy food.

Input subsidies, in many cases, intend to support poor farmers who can benefit from increased access to inputs.[18] The eventual goal of input subsidies is, in theory, to encourage incremental use of inputs by those who would otherwise not use them, and to build demand by improving knowledge and skills on the effective use of inputs.[19]

However, in many cases agricultural subsidies do not reach the farmers that need them the most. Subsidy schemes can become a hotbed for corruption and fraud, be costly to administer, and risk unintentionally benefiting the wealthiest farmers if no well-designed targeting mechanisms are in place. For example, fraud can occur if subsidy vouchers are too easy to counterfeit, as is the case with many paper-based voucher programs. Typical fraud also includes "ghost recipients"—false names or names of deceased beneficiaries in whose name someone collects the subsidy—or double-dippers who collect more than the allocated benefit under the same or different names.

A robust foundational ID system can improve the effectiveness of subsidy programs and reduce fraud and leakages by providing a unique and verifiable identity, which can be linked to subsidy delivery (and

17 Worldwatch Institute. 2014. "Agricultural Subsidies Remain a Staple in the Industrial World" http://www.worldwatch.org/agricultural-subsidies-remain-staple-industrial-world-0 Note that evaluating the effectiveness of different subsidy schemes is not within the scope of this paper; rather, the discussion will focus on the intersection between agricultural subsidies and ID, and will be mostly relevant to developing countries.

18 There may be other, unstated intentions of agricultural subsidies, such as patronage by certain political parties, but these will not be considered here as they are beyond the scope of this research.

19 World Bank. 2008. New Approaches to Input Subsidies.

collection). A foundational ID system, which is also closely integrated with the civil registry, can ensure that critical data for subsidy delivery, for example on deceased recipients or to account for the expansion of a household, such as the birth of a child. A growing number of foundational ID systems also offer robust identity verification and authentication mechanisms, such as biometric matching of the beneficiary's identity against the central registry or against information stored on their ID card, which helps ensure that only those entitled to the subsidy or another benefit can collect them.

A unique identity could also be provided through a *functional* identification system, created solely for the purpose of administering the agricultural subsidy program. However, verifying identities at the time of enrollment based on multiple potential sources and documents, de-duplicating records, issuing program-specific credentials, and establishing reliable authentication mechanisms increases both time and costs substantially. In addition, keeping the data up to date in the functional systems would pose additional

Box 2: Lessons from Nigeria's GES Subsidy Pilot

In 2014, the government of Nigeria supported a pilot project to digitize agricultural subsidies under the national Growth Enhancement Scheme (GES). The intention was to tackle corruption and prevent fraud that kept eligible farmers from receiving their intended subsidies under the scheme. At the time, Nigeria did not have a robust, high-coverage foundational ID system to identify recipients. Although many farmers had a voter ID, the voter identification number was not held by all potential beneficiaries and was not unique, as duplicate numbers had been issued during the registration process. Therefore, the pilot system accepted 10 different forms of ID for enrollment. Despite that, about 14 percent of farmers did not have a qualifying identity document. For these farmers, the pilot created a system of sponsorship where one person could vouch for the identities of up to four other people. The pilot successfully registered 500,000 farmers, and 85 percent redeemed their vouchers. Despite this success, there was significant extra time and cost devoted to work-arounds due to the lack of a foundational ID system that could assure the unique identity of each farmer.[20]

In addition to the challenges associated with the lack of a foundational ID system, there was also limited mobile connectivity and electricity in rural areas targeted by the subsidy program, requiring the pilot to develop a specialized off-line, solar-powered point-of-sale device for registering and authenticating farmers. The program also relied on facial recognition, which did not work as effectively as expected at the time: the color tones of farmers' skin were not different enough to be recognized by the available software in some cases, and in other cases the software was confused by the patterns in the background (often, farmers' photos were taken against a cinder block, which was highly textured).

The accuracy and capabilities of facial recognition software has improved since 2014; however, it is important to recognize that not all biometrics work in all contexts, and that farmers in rural areas can present unique challenges.[21] Challenges with mobile connectivity, electricity access, and lack of a universal foundational ID are unfortunately still present in many rural areas, especially in developing countries, and will have to be taken into account when considering any application of digital IDs for agriculture.

20 Interview, Paul Makin, May 2018. This experience is specific to one pilot that involved Consultant Hyperion in 2014, and does not reflect later efforts by the government of Nigeria to digitize subsidies.

21 For more on factors to consider when implementing biometrics, see, for example "The Biometric Balancing in Digital Finance," CGAP Blog, June 2018. http://www.cgap.org/blog/biometric-balancing-act-digital-finance

resource-intensive administrative challenges, particularly if the functional system would not be interoperable with other, relevant databases, such as the civil registry.

Recognizing the benefits of foundational ID systems, many countries are working to leverage ID systems for their own agricultural subsidy efforts. For example, in Uganda, the Ministry of Agriculture, Animal Industry and Fisheries is currently planning an e-voucher subsidy scheme that will be rolled out to 450,000 farm families in 42 participating districts. The scheme is designed to rely on the national ID to uniquely identify farmers who will receive targeted subsidies for the purchase of agro-inputs (seeds, fertilizers, pest control chemicals, and postharvest handling materials) via mobile phones.

India has transformed the country's agriculture subsidy programs by linking them to the country's "Aadhaar" ID system (see Box 3), despite physical and digital infrastructure challenges. The experience of Estonia, a country with fewer infrastructure challenges, is presented in Box 4.

Box 3: India Transforms Agriculture Subsidies through Foundational ID

India offers a prominent example of how a foundational ID system and agricultural subsidies can complement each other. In fact, it was the inefficiencies observed in 2005 by the Government of India (GoI) within various subsidy schemes that originally inspired the idea to create a foundational ID system with the capability to uniquely identify each person in the country. This idea has since transformed into Aadhaar, the world's largest biometric digital identification system, which issued a unique 12-digital number for more than 1.2 billion Indian residents.

The unique 12-digit Aadhaar number is issued following biometric de-duplication, and individuals can then use this number to identify themselves when they want to access an Aadhaar-linked service. Depending on the desired level of assurance, the authenticating service agency may ask for some combination of demographic data, a fingerprint, or a one-time password (OTP). Aadhaar authentication queries from third-party users to the central database return a simple "yes/no" response, indicating whether or not the person's asserted identity factors match government records (maintained by the agency responsible for Aadhaar, the Unique Identification Authority of India, or UIDAI).

Aadhaar is now mandatory for India's various subsidy schemes. There are at least two subsidy schemes directly relevant to smallholder farmers: one that distributes subsidized fertilizer, and the large-scale Public Distribution System (PDS), which provides subsidized food to the majority of rural residents.[22] In both cases, Aadhaar has been integrated into the program registries and is linked to the collection of subsidies in order to eliminate the fake and duplicate identities that plagued the system before the introduction of a unique identifier.[23] The Government of India estimates that as of early 2018 that it saved significant funds across its social programs and subsidy schemes, mainly by reducing fraud.[24] Reducing fraud and leakages frees up scarce government resources for productive use and helps ensure that only those who the subsidies are intended for receive them. The use of

22 Other major social protection schemes include the Employment Guarantee, Government Pensions, and the Essential Commodity (cooking fuel) subsidies. For more, refer to State of Aadhaar 2016–17. http://stateofaadhaar.in/wp-content/uploads/State-of-Aadhaar-Full-Report-2016-17-IDinsight-1.pdf

23 Omidyar Network. 2018. "A Perspective on Aadhaar" April 13. https://www.omidyar.com/blog/perspective-aadhaar

24 World Bank. 2018b. The exact amount of funds saved is contested. For more information, refer to "Public Sector Savings and Revenue from Identification Systems: Opportunities and Constraints." http://pubdocs.worldbank.org/en/745871522848339938/PublicSectorSavingsandRevenueIDSystems-Web.pdf

robust identification and authentication improved user confidence in the system: a majority of beneficiaries interviewed for the 2017–18 State of Aadhaar Report confirmed that they are confident that no one else can access their ration because biometric authentication prevents identity fraud.

Nevertheless, concerns remain that some genuine beneficiaries may be excluded from the subsidies due to failures in authentication and issues with integration of the Aadhaar number with beneficiary registries. Some recipients also complain that they can no longer send a family member as a proxy to pick up their ration. To ensure that no one is left behind, it will be important that any reports of exclusion are rapidly investigated and addressed.

The Aadhaar-enabled public programs have already begun to implement certain improvements to address the challenges of operating in rural areas and serving vulnerable communities. For example, new forms of authentication were enabled when it was discovered that many farmers' fingerprints were too worn from manual labor to successfully use fingerprint scans. When biometric authentication fails for any reason, owners of authorized redemption locations are allowed to use a manual override for genuine beneficiaries.

India's case also illustrates how the transformational potential of foundational identification systems can be maximized when coupled with additional efforts to increase digital and financial access. The GoI conceptualized Aadhaar as part of the so-called JAM trinity: (1) financial access through Jan Dhan accounts that come with zero balance requirements and offer access to additional products, such as insurance and an overdraft facility; (2) unique identification through the Aadhaar number; and (3) digital inclusion through increased access to mobile phones and mobile connectivity. In many cases, subsidies are paid directly to Jan Dhan accounts, giving previously unbanked recipients an opportunity to save and to continue transactions through digital channels.[25] On the whole, these efforts highlight the potential benefits of leveraging a foundational ID system for better development outcomes for farmers and in agriculture more broadly, and can contribute to achieving the GoI's goal to double farmers' incomes by 2022.[26]

Without a robust foundational ID system, agricultural subsidy distribution is extremely difficult. Malawi, for example, attempted to digitize the country's Fertilizer Input Subsidy Program (FISP) in 2014, which was implemented before the national ID system was put in place. The effort to move from paper to electronic vouchers (e-vouchers) was motivated by the recognition that paper vouchers were easy to forge, and that many farmers were not receiving their allocated subsidy due to the prevalence of counterfeit vouchers. However, the e-voucher pilot faced many challenges. Since there was no de-duplicated digital registry with universal coverage, it was hard to uniquely identify farmers, many of who had similar names, and/or shared a phone number with several others in their village. The program therefore created a new (functional) ID number for each person, but this number was not known or recognized by any other program, and it was difficult to match a person to a number if there was an issue with the subsidy. In addition, mobile connectivity was a problem, as the text messages delivering the e-vouchers were not always received. Finally, the basic phones that most farmers owned offered limited functionality and presented challenges for redeeming the e-voucher through a USSD menu.[27]

25 This effort has generated some controversy, and has thus far demonstrated limited success getting recipients to actively use the simplified bank accounts. This discussion, however, is beyond the scope of this paper.
26 Ramada, Sendhi, and S. J. Balaji. 2017. "Transforming Indian Agriculture," Research Gate, September.
27 USSD stands for Unstructured Supplementary Service Data. It is a communication channel that is often used to facilitate conversations on a basic phone, as it is less expensive for a back and forth exchange than text messages (SMS).

In the absence of a foundational ID system, many developing countries will experience similar challenges as Malawi and Nigeria. Many may find, like India, that a unique foundational ID is a necessary precursor to implementing a widescale digital subsidy program. India's experience will continue to be highly illustrative as the country has struggled with, and tackled, many challenges, and continues to make improvements to its foundational ID system as well as the Aadhaar-enabled public programs. India's experience also offers some lessons in making adequate provisions for data protection and safeguarding privacy (which will be discussed in Section 4).

On the other end of the spectrum, the experience of Estonia included in Box 4 describes how agricultural subsidies can be efficiently delivered when there is a universal foundational ID and robust digital infrastructure.

Box 4: e-Estonia Tackles Agricultural Subsides

Estonia is unique in terms of its adoption of digital governance. The government has brought 99 percent of public services online and has enabled online identity verification and authentication via an interoperability platform called the X-Road, connecting various functional registries and the country's foundational, digital ID system. Ninety-eight percent of Estonians have an eID and can access various public and private services and transactions, and even vote remotely from anywhere in the world. In addition, through the e-Residency program, anyone with a government-issued ID from around the world can apply to become an Estonian e-resident and start a company, conduct financial transactions, and file taxes remotely online, even if they have never visited the country.[28]

For Estonia's farmers, this means that their agricultural subsidies are integrated with both the e-ID and X-Road, the national electronic infrastructure which integrates the nation's various databases and registries. This allows farmers applying for agricultural subsidies to apply online using data that they have already provided to the government, as the government committed to never asking an individual to supply information multiple times that had already been recorded in an X-Road connected database. As a result, farmers now spend 45 minutes on subsidy applications, down from 300 minutes using the previous paper-based system. This also reduced the delays in paying out subsidies in Estonia. In addition, farmers can also register land and cattle remotely online and access detailed geographic and soil-related information through X-Road.[29]

Land and Assets Registration

In order to professionalize and commercialize, farmers must be able to record asset ownership, including land, livestock, and other business assets. Land registration is recognized as a core element for improving land governance as part of the Agenda for the Global Food System to End Poverty by 2030.[30] It is also a critical part of at least three Sustainable Development Goals, including Goal 2, which sets out to:

28 See https://e-resident.gov.ee for more details on the application requirements and services associated with Estonian e-Residency.
29 Kärner. 2017. "The Future of Agriculture is Digital: Showcasing e-Estonia," *Frontiers in Veterinary Science,* September. https://www.frontiersin.org/articles/10.3389/fvets.2017.00151/full
30 Townsend, Robert. 2015. *Ending poverty and hunger by 2030: an agenda for the global food system,* World Bank Group. http://documents.worldbank.org/curated/en/700061468334490682/Ending-poverty-and-hunger-by-2030-an-agenda-for-the-global-food-system

> "*End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.* By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through ***secure and equal access to land,*** other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment." [own emphasis added].

Land registration has many benefits for smallholder farmers, including providing official proof of owning collateral that can be used to access loans and other financial services, contributing to the robust farmer profiles (discussed in the next section), and protecting against title fraud. Yet, land registration is a challenge in many countries, especially for smallholder farmers, as a farmer will need a government-recognized form of identification in order to register land ownership. Moreover, as land is usually passed down to family members, civil registration documents, such as birth and marriage certificates, are also critical to secure families' rights to their land across generations.

Identification can support registration in two key ways. First, foundational ID systems can ensure that farmers have proof of identity and proof of familial relationships needed to register land and assets in their own name. Second, if registries are interoperable, a unique, foundational ID number can be used to link records across databases (land, assets, livestock), which can improve the efficiency of service delivery, creating benefits for both the government and the farmer. Farmers will also be able to more easily demonstrate to potential service providers (such as a financial institution) the ownership of all of their assets.

Identification is only one aspect of creating robust land and asset registration systems. For instance, for digital registries linked to foundational ID systems to work well, the 'input' data on land and assets and their ownership must be carefully verified before being recorded. This can pose a significant challenge. Even in India, where the Aadhaar number is ubiquitous, linking it to land records could not solve other challenges with legal land title systems or the high prevalence of land under dispute (around 10 percent).[31] Therefore, while unique, foundational IDs can be critical for asset registration, especially for individual smallholders who are not registered as an enterprise, they must be considered as one factor within the context of a broader set of necessary reforms to enhance the integrity of registries and to ensure that they serve the poor well.

The example of Estonia, described in Box 4, offers a potential good practice to increase the transparency of land registration systems. Since the interoperable X-Road platform connects the databases of Estonian Land Board, e-Land Register, and Estonian Agricultural Registers and Information Board, it is easy to find information on land registration, including registration number, intended land use, soil type, protected area restrictions, land owner, and land user. Unlike in many other countries, these data are open and accessible to the public, and trust and security are assured by authentication through an e-ID.[32]

However, not all countries may be able to rely on the digital infrastructure and interoperability frameworks underpinning Estonia's X-Road in the near term. The examples of Malaysia and Uruguay in Boxes 5 and 6 provide additional details on countries that have leveraged foundational ID systems for registration without the level of interconnectedness provided by X-Road.

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31 Chari and Shrivastava. 2017. "Fertiliser reforms were linked to digitised land records" Scroll.in, October 11. https://scroll.in/article/853482/fertiliser-reforms-were-linked-to-digitised-land-records-but-the-database-is-far-from-complete

32 Kärner. 2017. *Frontiers in Veterinary Science.*

Box 5: Malaysia Uses Foundational ID to Address Title Fraud

Malaysia has a robust foundational ID system. The original, paper-based system (which was started in 1949) was eventually replaced with a digital ID system called the MyKad. The MyKad system leverages a smart card, which includes a picture and a chip that contain the holder's fingerprint biometrics.

The country also performs well for land administration globally. It ranks 42 out of 190 jurisdictions in the ease of registering property in the World Bank's annual Doing Business rankings, a significant improvement from 2010, when the country was only ranked 86th. The stark improvement was brought on through concerted effort on many fronts, including an overhaul of the business processes involved in land registration.

As part of this overhaul, the government of Malaysia introduced the obligatory use of the MyKad for land registration and installed fingerprint readers as a means of reducing fraud and forgery. The fingerprint readers allow anyone who wants to register a piece of land to authenticate their identity using their MyKad smart card. In this case, the land registration system uses the foundational ID system to assure that the individual is who they claim to be, reducing land disputes and loss of land rights that resulted from fraud in the past.[33]

Farmers may also need a government recognized ID to officially register their livestock. Similar to land, this allows livestock to be leveraged for financial services (e.g., as collateral), and also helps create access to new markets, as remote buyers are able to verify that livestock or produce is available for purchase and can view its origin. Accurate livestock registration has the additional, critical benefit of helping to quickly trace the source of any public health threat, such as food contamination or livestock disease. This was the original motivation for the successful livestock registration program established in Uruguay highlighted in Box 6.

Box 6: Uruguay Becomes a Global Exporter through Livestock Traceability

Uruguay has become a leading exporter of meat since implementing a livestock traceability system. The setup of the system was initially motivated by an outbreak of foot-and-mouth disease in 2000 and 2001, which led to the overhaul of the paper-based system that had been in place for the previous 30 years. The government financed the traceability system, creating a sense of pride in what was recognized by farmers as a publicly owned asset—a factor that supported uptake and broad participation. Participation in the system was initially voluntary but became compulsory after a successful pilot. The cattle are associated with each individual farmer, based on his/her national ID. When a farmer needs to identify new calves, he/she can request tags online or by phone, and the tags are delivered within 24 hours, along with a printed form including the farmer's name, ID number, the name of the business, and the numbers of the tags being sent. The farmer only has to add the gender, breed, and age of the animals, plus the date on which the ear tags were attached, and return the paperwork by mail, where the form is scanned, and the information included in the electronic system.

(*continues*)

33 World Bank 2017a. "Enhancing Public Sector Performance: Malaysia's Experience with Transforming Land Administration," The World Bank Group, November. http://documents.worldbank.org/curated/en/928151510547698367/pdf/121243-REVISED-World-Bank-Report-06-Land-Administration-FA-FULL-Web-V2.pdf

In meat processing and packing plants, the products obtained from the animals are labeled with bar codes linking them to the herd from which they originated. This identification is retained practically up to the point of sale. As a result, buyers can be confident of the origin of their meat and can even visit the individual farms to see their quality and management. Thanks to the livestock traceability system, Uruguayan farmers have gained access to the European Union export market and are able to charge higher prices than those paid for the production of direct competitors like Australia, Brazil, and Argentina.[34]

Unique Farmer Profiles to Improve Service Delivery

There is a growing focus on the importance of digital farmer profiles given their potential to remove one of the bottlenecks for provision of more targeted services to farmers. These profiles, which can be owned and operated by government agencies or private service providers, are currently being piloted in several countries. Such profiles may take different forms, but in general contain key pieces of information about the farmer that can be used by service providers to better serve the farmers. This may include information such as: farmer and household demographics, education, farm practices, financial assets and services used, farm environmental conditions, size of the farm, GPS coordinates, land ownership, crops grown, and income and income sources.[35] Subject to robust data protection and privacy safeguards, linking such profiles to foundational IDs ensures that the profiles are connected to other services that farmers require, especially government and financial services. Robust farmer profiles may also be leveraged to help individual farmers connect to new supply chains, such as those for organic produce, by supporting supply-chain traceability and transparency.[36]

For example, detailed farmer profiles can also allow for more targeted, specific extension advice to be delivered to each farmer to help improve productivity. In Uganda, a start-up called Akorion is building farmer profiles and providing this data (with the farmer's consent) to banks and insurance companies that can then provide targeted financial services to the farmers.[37] In Kenya, Digifarm allows farmers to create profiles containing information on the size of their farms and the nature of the farming activities. Farmers can also access a variety of discounted inputs, advice, and financing. The information collected is anonymized and shared with the government for long-term planning related to food security. Finally, Digifarm is linked to local depots to facilitate the distribution of physical goods, such as high-quality inputs in partnership with private agricultural distributors.[38] Neither the service in Uganda nor in Kenya is directly integrated with the national ID system, but profiles can be linked to the national ID number.

The experience in Malaysia outlined in Box 7 is a good example of how this may happen at a national level.

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34 IICA. 2013. "Traceability, a source of pride for Uruguay's livestock subsector," Inter-American Institute for Cooperation on Agriculture, January. http://www.iica.int/en/press/news/traceability-source-pride-uruguay%E2%80%99s-livestock-subsector

35 Results of Farmer Profile research conducted by Grameen Foundation, FHI360, and USAID. https://nextbillion.net/serving-smallholder-farmers-in-the-digital-age-why-it-requires-treating-data-like-an-asset/

36 Wilson. 2018. "Digital Identity for Smallholder Farmers: Insights from Sri Lanka," GSMA. https://www.gsma.com/mobilefordevelopment/programme/digital-identity/digital-identity-for-smallholder-farmers-insights-from-sri-lanka-2/ Note that in this report, the term "economic identity" is used in place of "farmer profile." This report uses the term used by Grameen Foundation, USAID, and others, "farmer profile," as to avoid confusion between national foundational identity systems and the term "economic identity."

37 www.akorion.com

38 "Safaricom Launches Digifarm Depot in Burnt Forest Town to Bolster Agribusiness," May 2018, https://www.safaricom.co.ke/about/media-center/publications/press-release/release/444

Box 7: Malaysia Leverages National ID for Farmer Profiles and Extension Services

In Malaysia, due to the ubiquity of the myKad ID card and its open technical design, each government agency can build its own applications on top of the national ID system. This allows the government agency to benefit from the fact that there is already a foundational ID system available to verify the unique identity of the individual, while building a functional ID specific to agency needs on top of this foundation. In the agricultural sector, the Federal Agricultural Marketing Authority (FAMA) introduced two identity-related applications derived from MyKad: one specifically for farmers, e-Pasartani, and one for fishermen. These applications are used to record data and information on participation in farmers' markets throughout the country. The applications use MyKad as a platform for storing data and information on the participants, including personal details and business licenses. It is connected to Famaxchange, an agricultural marketing information portal developed by FAMA to improve the efficiency and effectiveness of information dissemination to the target groups.[39]

Similarly, a recent GSMA study on digital identity for smallholder farmers in Sri Lanka found that farmers, especially young farmers, expressed a desire for more accurate information on crop prices and demands to help them deal with fluctuations in prices. Through their research, GSMA identified a business opportunity for mobile network operators (MNOs) to provide this type of targeted information to farmers. MNOs could start with a simple profile in which farmers add their own information. This could then be combined with information such as airtime purchases and external sources, such as data from agribusinesses who transact with each farmer, following the consent of the farmer for information sharing. This information, combined with a government-recognized ID to satisfy KYC and CDD requirements, could be used for farmers to receive higher value loans and help their businesses grow. With permission from the farmer, this information could also be shared with insurance providers to facilitate access to appropriate insurance that would protect farmers in the case of disasters such as drought or flood. Farmer profiles leveraged in this way could greatly help close the gap for access to financial services for smallholder farmers.[40]

39 ADB. 2016. "Identity for Development in Asia and the Pacific," ADB https://www.adb.org/publications/identity-development-asia-and-pacific. See also: http://www.jpn.gov.my/en/informasimykad/aplikasi-tambahan/#1458812952073-1a4b23d4-f523

40 Wilson, 2018.

4. Data Protection and Privacy

Many of the services described in this paper require data sharing between various entities, such as agribusinesses, financial institutions, and government agencies. This requires additional consideration for data protection and privacy safeguards, as per the *Principles on Identification*.[41] While ensuring data protection and safeguarding privacy are challenging everywhere, applications of digital ID in agriculture present specific challenges, including with regard to gaining informed consent for data collection and sharing. This is in large part because individuals in rural areas tend to have lower education and digital literacy levels than those in more urban areas, with women in rural areas often having the lowest level of educational attainment.[42]

Any projects that plan to leverage a foundational ID will need to consider how to ensure that smallholder farmers fully comprehend their rights as they relate, inter alia, to the collection, use, and sharing of their personal data. This could mean taking extra time to verbally explain agreements to farmers, and/or to explain terms and conditions through multimedia content, such as cartoons, low-cost videos, or interactive voice response (IVR).[43] Digital solutions can help, depending on the context and population group. For example, a project in Mozambique that used biometrics to register participants for opening a bank account found that women were much more comfortable providing a fingerprint than a signature to confirm their consent to the terms of the account, since they often did not know how to sign their name.[44]

In another example from Tanzania, researchers tested three different tools for obtaining informed consent to participate in a research study with livestock farmers. Of the three tools tested—a written form, a poster with cartoons, and a poster with photographs—the poster with cartoons proved to be the most effective among the (albeit small number of) participants. In a separate study with informal milk vendors in Kenya, the researchers found that participants preferred verbal consent over a written signature or thumbprint. These studies highlight that verbal and visual methods of explaining terms and conditions in order to ensure that they can provide truly informed consent may be more appropriate for smallholder farmers in rural areas.[45]

Although countries are systematically advised to have robust data protection laws and incorporate 'privacy by design' into the architecture of digital ID systems, most of them still lack adequate legal frameworks to support and regulate modern identification systems. Therefore, ID4D initiative has developed the ID Enabling Environment Assessment (IDEEA) tool to assist governments in developing legal frameworks that promote trust in the design, implementation, and use of ID.

In parallel to strengthening the legal and regulatory frameworks in developing countries, there is a need to also think through "privacy by design" (PbD) features that can be embedded into digital identification systems to reduce data protection risks and provide people, including those with a low literacy rate, greater control over their data. For example, minimal data collection, the use of randomized identification numbers, and tokenization are examples of PbD features already being deployed in a few digital

41 World Bank. 2017b. *Principles on Identification for Sustainable Development.*
42 CGAP National Survey of Smallholder Households in Mozambique and Tanzania.
43 See, for example, "Multimedia informed consent for low literacy populations," The Global Health Network, 2016 https://globalhealthtrials.tghn.org/articles/multimedia-informed-consent-low-literacy-populations/
44 Interview, Kathryn Larcombe, The World Bank Mozambique, May 2018.
45 Macmillian, Susan. 2016. "On more rigorous informed consent in One-Health cross-cultural livestock research," May. https://clippings.ilri.org/2016/05/19/on-more-rigorous-informed-consent-in-one-health-cross-cultural-livestock-research/

identification systems globally. A few examples are highlighted in "Privacy by Design: Current Practices in Estonia, Austria and India," recently published on the ID4D website. There is a lot of research going into this area, and innovative solutions are being developed which will likely be highly relevant to agricultural applications that leverage personal data.

In addition to informed consent and built-in PbD features, data sharing should only happen with appropriate consideration for when and how to anonymize and/or encrypt data before sharing it. While these technical details are beyond the scope of this paper, they are important within the realm of agriculture. There is more information on these issues provided in related ID4D resources.[46]

46 See http://id4d.worldbank.org/research

5. Conclusion

An overview of how different countries have thus far applied foundational ID systems to support farmers demonstrates the potential for identification to help tackle key challenges in agriculture and support smallholder farmer productivity. Effectively leveraging foundational ID systems for agriculture can contribute to meeting the goals set forth in the SDGs and ensuring that smallholder farmers are equipped to meet the demands of global food security. Each application, when designed appropriately and with potential barriers and risk mitigation in mind, can help to overcome critical challenges faced by smallholder farmers—lack of access to financial services, lack of sufficient supply-chain traceability, challenges related to the delivery of goods and services, and disadvantages faced by female farmers.

Subsidies, land and asset registration, and digital farmer profiles all have a role to play in addressing the tremendous need to increase smallholder farmers' *access to financial services,* including savings, credit, and insurance. Identification is a critical starting point to closing this gap, since government recognized IDs provide the necessary proof of identity for Customer Due Diligence (CDD) requirements to open a formal financial account or register for a SIM card. In addition to helping to open an account, robust identification can also drive usage and uptake of other financial products by enabling farmers to utilize data from a number of sources to create a credit history that can help financial institutions better serve smallholder farmers to grow their businesses.

These applications can also facilitate *supply-chain traceability.* Traceability increases access to export markets and helps to quickly identify the source of any public health issue originating in the food supply. Asset registration can greatly facilitate supply chain traceability, especially if there is a foundational ID system that can link assets, such as land and livestock across databases, as is the case in Estonia. A unique foundational ID can also support the creation of digital farmer profiles, which enables service provides to better tailor their services.

These farmer profiles are also a way to improve *the delivery of goods and services.* Linking farmer profiles to unique IDs can help service providers to better identify and locate smallholder farmers and design programs more closely targeted to their needs. It can also support the provision of relevant, targeted information and advice to farmers. Aggregated data may then be shared with relevant government authorities or other partners, who can use it for decision making and planning and to more effectively allocate resources, such as inputs and subsides, to different regions.

Finally, through appropriate application in agriculture, foundational ID systems can help *empower female farmers.* Removing barriers to access and ensuring universal ID coverage in rural areas can help prevent women farmers from being unintentionally excluded from services critical to their business, such as registering for their own mobile SIM card or opening their own bank account. Female farmers with unique IDs will also be better able to establish an accurate farmer profile (where available) in their own name, helping to ensure that women are able to create the robust economic identity that they need to increase their own productivity.

To take full advantage of a foundational ID system, there is some level of enabling infrastructure that is required for each of the applications. This includes information and communication technology (ICT) infrastructure and a well-enforced legal and regulatory framework for data protection and privacy. When countries try to digitize the delivery of agricultural subsidies before the implementation of a foundational

ID system or sufficient mobile connectivity, they will likely struggle to do so, as shown in the case of the GES pilot in Nigeria and the e-voucher experience in Malawi.

Having a robust legal and regulatory framework in place related to the foundational ID system and data protection, privacy, and cybersecurity more broadly, is critical to mitigating any risks associated with implementing ID systems while ensuring their long-term sustainability and maximizing the benefits they can provide for development.

Looking Forward

By serving as a platform for the effective implementation of subsidy schemes, asset registration, and digital farmer profiles, foundational digital ID systems can help farmers and countries overcome critical challenges in agriculture. Where countries have already developed a robust foundational ID system that provides a unique ID for all citizens and residents, agricultural applications can greatly benefit. Where this enabling infrastructure is not in place, public and private actors can still benefit from creating functional ID systems for their own purposes; however, verifying identities and establishing uniqueness for each functional system tends to be very costly and can pose an additional burden on their intended beneficiaries. Thus, while the presence of a foundational ID system is, in the strictest sense, not a requirement to enable robust identification for agricultural applications, it introduces efficiencies that can help to achieve scale and lower the cost of implementation and authentication.

Going forward, it will be important to better understand how safeguarding data privacy and informed consent translate to rural contexts, particularly as new digital technologies are being introduced. In addition, there should be more attention paid to how to enable people in areas with poor or no connectivity to authenticate themselves in a secure and cost-effective way. This is particularly important when accessing financial and other services that require a relatively high level of identity assurance. As "Privacy by Design" tools are tested and deployed, it will be important to consider how these can be applicable to smallholder farmers.

Finally, countries may experience institutional and coordination challenges between foundational and functional ID systems, especially in contexts where foundational systems are planned but not yet implemented. While this challenge was not explicitly addressed in the case studies reviewed for this paper, it is a significant consideration when planning for future applications of ID in agriculture.

Advancing the understanding of the early experiences and lessons learned will help governments ensure that ID systems and their applications are designed to maximize opportunities for smallholder farmers, while minimizing the risks and barriers that are often unique to rural areas and poor, marginalized populations.

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