Study and recommendations

Data sovereignty in agricultural value chains

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I. EXECUTIVE SUMMARY

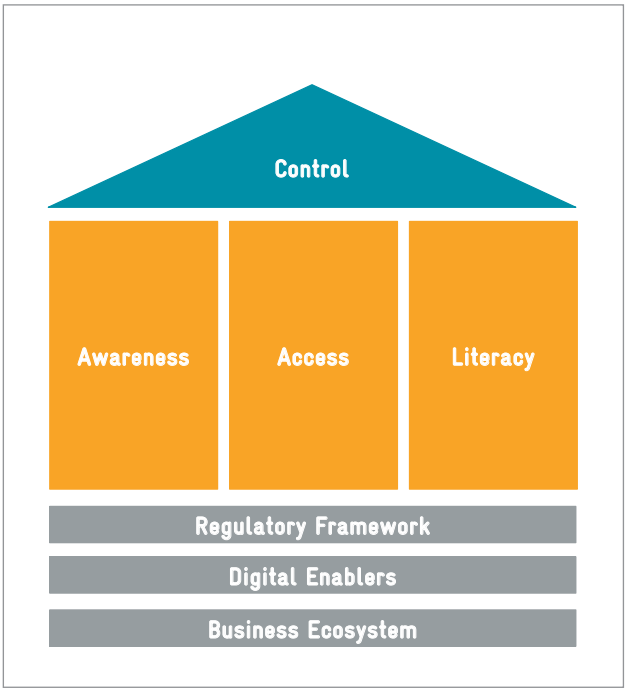
Digitisation is accelerating the transformation of the agriculture sector in low- and middle-income countries (LMICs) at an unprecedented rate, generating large amounts of digital information or "data" that has implications for smallholder farmers. As the food and agriculture sector supports a growing, migrating, and aging population, players in the industry are increasingly thinking about how to reshape global food production and supply chains to meet consumer demand and ensure food security. Digitisation plays a key role in this agricultural transformation, with various technological advancements resulting in the large-scale generation of data from farmers, agents, or through the usage of digital systems and sensors. Smallholder farmers typically have the least amount of agency or control over this data, including their personal data; as a result, they do not sufficiently exercise their data privacy rights nor equally benefit from the value of their data.

At its core, agricultural data can afford smallholder farmers the opportunity to unlock new business and opportunities derived from its value, yet existing constraints around key enablers limit their capacity to control their own personal data. We define and conceptualise data sovereignty using a framework that outlines the key individual, organisational, and ecosystem enablers of control. By this definition, farmers cannot adequately exercise full control over their data without a sufficient level of access, literacy, and/or awareness of the data, or outside a more broadly enabling regulatory, digital, and business environment. Based on conversations with industry stakeholders, these enablers currently rank low to non-existent within agricultural value chains across LMICs, leaving smallholder farmers in these markets with virtually no data control. On a practical level, exercising control can include the action of or provision of consent for data collection, processing, and sharing, as well as data monitoring and the removal of access to data.

If successfully implemented, there are clear business and impact cases around data sovereignty for smallholder farmers that can allow them to generate direct income, in-kind value or non-monetary gains, or other kinds of indirect benefits. For example, farmers can sell their data for money, most profitably by commercialising aggregated data as opposed to individual data, the latter of which does not have significant economic value. Farmers who engage in sustainable farming practices can also monetise their data as price premiums on fair trade products or through carbon markets. Alternatively, farmers can exchange their data for in-kind value such as advisory services or as a means of informing the design of improved products, services, and public policy.

Low data sovereignty in agricultural value chains presents risks and missed opportunities. Three types of interventions have been identified that can be undertaken to strengthen farmer control over data: indirect, intermediary, and direct. For farmers, low data sovereignty costs opportunity. The unfair redistribution of the benefits derived from their data results in farmers not meaningfully participating in the design of agricultural services and products; they are faced with limited product choice and breaches of privacy that could result in discrimination. Supporters can respond by strengthening the enabling environment and capacity of farmers, indirectly increasing data sovereignty. As an intermediary step, work can be done to establish the foundational layer of a data sovereignty platform, a top-down effort that is driven and owned by the public sector. In more digitally mature markets, interventions can focus directly on enabling the usability and sharing of data with the private sector, for example, by establishing standards that enable data portability and interoperability.

Figure 1: Data Sovereignty Framework



The operationalisation of data sovereignty (that is, how farmers' personal data is protected collected, accessed, shared, and used), can be achieved using different models, most of which revolve around a personal data store (PDS) controlled by farmer or data cooperatives. The PDS, which is connected to different data production, storage, and processing systems, is used by farmers or data cooperatives to exercise different levels of control, such as consent provision. Operating models include: *(i)* Data sovereignty siloes, where personal data remains siloed and is not exchanged with third parties, *(ii)* 1-to-1 Data sharing where data is exchanged between two organisations bypassing the farmer or the data cooperative, *(iii)* Data ecosystem, where multiple digital solutions connect to a farmer's PDS allowing different providers to benefit from the data, and (iv) Data marketplace, where data cooperatives aggregate and centralise data from members to enable access and commercialisation of the data by a connected community of organisations. Each model presents different farmer-facing incentives and barriers to scale and requires tailored business considerations. These models are most financially sustainable when interconnected.

Among the considerations for implementation, the role of advanced technologies such as blockchain and other decentralised technologies should be explored, as should the trade-offs or parameters to optimise for when thinking about data sovereignty. The conversation around personal data protection cannot be had today without considering options for distributed forms of data exchange. Decentralised technologies like blockchain are already being leveraged by digital agricultural solutions to increase transparency, security, and immutability of data, and can therefore play a role in enabling more farmer control. However, the success of such technologies is contingent on certain preconditions being met, such as digital identification for all farmers. Other considerations push us to think of how to create a balanced enabling environment for data sovereignty that does not stifle innovation in the agriculture sector. Whether considering pathways to a seamless evolution of data management mechanisms or ensuring there are proper incentives, trust levels, user friendliness, and a means of inclusion for smallholder farmers, support actors need to confront the complexities in which data sovereignty should be optimised.

Various ecosystem players are already implementing data sovereignty solutions either through indirect, intermediary, or direct interventions, yet most existing interventions only address a small aspect of control, leaving room for more to be done. Government stakeholders like the Indian Ministry of Agriculture are developing national frameworks such as the Indian Digital Ecosystem for Agriculture (IDEA) or "AgriStack." These are aimed at strengthening the enabling environment for data governance and sovereignty. Other actors like Digital Green are working in close conjunction with the public sector through intermediary interventions that help to build a foundational layer for a data sovereignty platform. Through the Digital Agricultural Advisory Services (DAAS) project in Ethiopia, Digital Green is working with the Government of Ethiopia to implement FarmStack. This open-source protocol allows secure and trusted data transfers, enabling farmers to give consent to share their personal data with third parties. Where there is already a level of digitisation of agricultural value chains, other market actors are moving into direct implementation. The International Dairy Data Exchange Network (iDDEN), for example, streamlines the data exchange services and integration between dairy equipment and national dairy information systems while ensuring that dairy farmers retain control over their data.

Alongside strengthening the enabling environment to advance individual and ecosystem enablers of data sovereignty, key stakeholder groups can play strategic roles supporting the design, piloting, and scaling of viable and sustainable models and interventions.
Stakeholders can:

- **Shape thinking around priority market entry points for data sovereignty interventions** based on ecosystem readiness and mobilise resources around high-potential business and impact use cases;
- **Support mapping efforts of sector champions and flagship use cases**, and facilitate ecosystem matchmaking and partnerships as well as learning engagements;
- **Serve as technical support partners to private and public actors** in developing a knowledge and skills base for the business and policy advancement of data sovereignty;
- **Catalyse funding** either via grant programmes for pilot implementation of promising business and operational models or commercial financing for scaling, and advising governments on public spending; and

- Drive market demand for real data sovereignty solutions by articulating user needs and engaging business and policy leaders.

The current state of the data sovereignty landscape in agricultural value chains as outlined in this study bears implications for global development goals in improving the livelihood of smallholder farmers and ensuring food security for all people. A sound appreciation for the role that data sovereignty plays and for its importance relative to other sector-related challenges is needed to design effective solutions. Beyond the scope of this study, there also remain a set of questions that stakeholders will need to contend with – questions around the specific data opportunities in agricultural value chains, the nature of demand among smallholder farmers for data sovereignty solutions, and what a path to sustainability for such solutions may look like. These questions, and others, can only be answered through further investigation and continued targeted engagement of the public, private, and farmer communities.

II. INTRODUCTION

This report aims to explore data sovereignty in agricultural value chains with a focus on smallholder farmers in low- and middle-income countries (LMICs). We define data sovereignty as the capability of an individual or an organisation to exercise control over their personal and business data. Within agricultural value chains, this concerns the personal data or personally identifiable information that is collected on smallholder farmers as well as the information collected on their farm, and the level of control that they have over that information. Control over data can take many forms, including collection, provision of consent, monitoring, or removal of access to that data, and can be enabled or constrained by a range of factors as outlined in the report.

This study of data sovereignty in agricultural value chains is an important and timely effort not only because of the potential to unlock new opportunities for smallholder farmers but also due to the risks of maintaining the status quo regarding farmers' control over their data. As the situation currently stands, there is unfair redistribution of the value derived from data, an inadequate level of data-driven decision-making in product and service design, limited farmer choice over products and services, and even breaches of personally identifiable information. All these present as equally strong justifications to act with the goal of returning control over data to the farmer.

The study will, among other objectives:

(i) review the current state of data within agricultural value chains from a regulatory perspective;
(ii) provide a reusable framework with which to better understand data sovereignty;
(iii) assess how key parameters such as data literacy, portability, and transparency can foster producers' data sovereignty;
(iv) identify potential business and operational models enabling producers to sustainably generate value from their data; as well as
(v) map initiatives in the field along with lessons learnt.

Data sovereignty is an area of increasing importance for the GIZ Fund for the Promotion of Innovation in Agriculture (i4Ag), which is commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). This work aims to guide industry and sector support actors in supporting smallholder farmers, whose data sovereignty can be seen as a driver of additional benefits for them, leading to better livelihoods and more resilient and sustainable farming practices.

III. DIGITISATION AND DATA IN AGRICULTURAL VALUE CHAINS

3.1. The rise of digital agriculture

The global food and agriculture sector is facing numerous challenges as it tries to support an ever growing, migrating, and aging population; it struggles to ensure access to food for those at the bottom of the pyramid (people who earn less than $2 a day). Globally, approximately 820 million people currently suffer from hunger. A further 2.5 billion suffer from some form of micronutrient deficiency. With the global population projected to grow by a further 3.2 billion[1] by the end of the century – mostly in LMICs – the demand for food and nutrition will only continue to increase, along with the challenges to provide the poorest households access to the nutrients they need. In addition, climate change is already affecting the agricultural sector, with increasing climate volatility leading to more severe droughts, floods, and new pests and diseases. We therefore need to think about how to adapt and reshape our global agricultural production and supply chains to ensure we can improve the redistribution of resources and sustainably cater to future demand.

Digitisation offers great promise in accelerating agricultural transformation across the world. The rapid growth of digital technology over the last two decades has had a significant impact on almost every sector. The concept of an industry's digitisation has gone beyond simply employing digital tools to using technologies to transform entire business and operating models. In the agriculture sector, digitisation has enabled farmers to increase their productivity through improved access to updated knowledge on good agricultural practices, better markets and prices, credit for farm inputs, mechanisation of farm operations, and climate and ecological data.

All this means that farmers – including in LMICs – can simply use their phones to access resources that would have otherwise been unreachable in the past. Recent data supports the transformative potential of digitisation in the agriculture sector, showing it as central to any agricultural transformation strategy. According to a report by CTA on the digitisation of African agriculture, farmers reported a 50 % to 300 % improvement in yields when they integrated digital tools in their operations[2].

Challenges and gaps exist that limit or hinder adoption and the impact of digital technologies in the sector, which affects LMICs more acutely. Although the sector has undergone positive changes related to digitisation, there remain outstanding gaps in the utilisation of technology to improve food security and rural livelihoods:

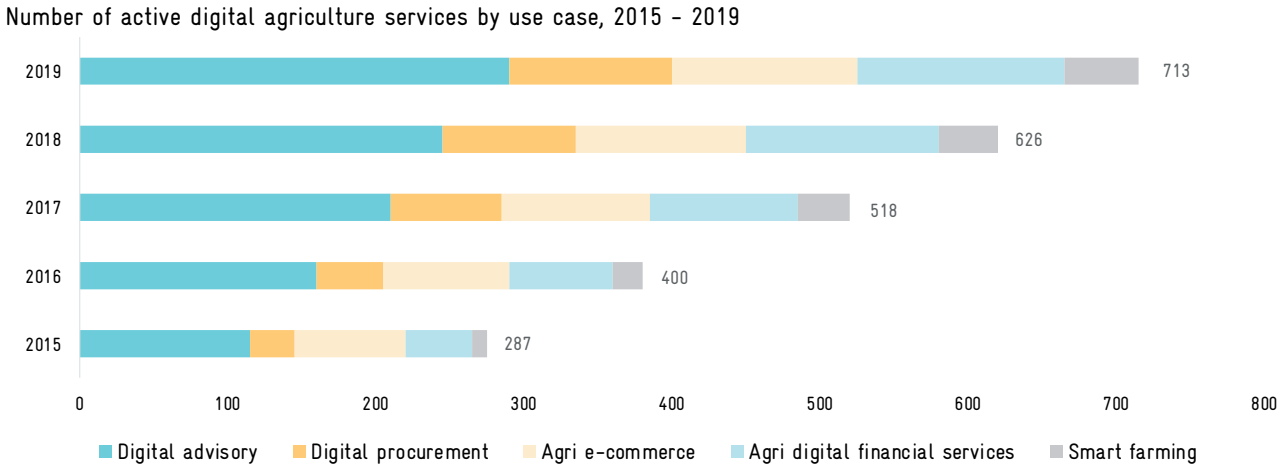
(1) Policy and regulation gap – limited and lack of digital policies that include or link to agriculture, as well as a lack of transparency and trustworthiness around data ownership and privacy;
(2) Modelling gap – missing business and operational models adapted to the needs and challenges of agricultural value chains in LMICs and catering for sustainability and scalability;
(3) Economic and gender gaps – costs of implementing technology solutions still remain unaffordable particularly in low-income countries, with women and disadvantaged groups more affected;
(4) Skills gap – limited digital literacy to utilise solutions;
(5) Digital divide – inequitable access to enabling infrastructure and information.

Box 1. Trends in the digital agriculture sector in LMICs

Digitisation in agriculture aims to ease and increase access to services, markets and assets. Access to digital advisory services are the most prevalent use cases, for example, enabling farmers, aggregators, and even consumers to conduct product verification of inputs and outputs. Smart farming techniques that leverage sensors and decentralised ledger technologies (DLT) are the least prevalent, although growth trends from 2015 indicate an increase adoption and use.

Figure 2: Common use case of digital agriculture solutions

Access to services	Digital advisory	Weather information; Pest and disease management; Product verification; Record keeping; Smart advisory; Agri VAS
	Agri-digital financial services	Credit scoring; Credit and loans; Input financing; Insurance; Savings; Digital agri-wallets; Crowdfunding; Accountability tools
Access to markets	Digital procurement	Digital records (with and without payments and traceability)
	Agri e-Commerce	Inputs and Outputs
Access to assets	Smart farming	Equipment monitoring; Smart shared assets; Livestock and fishery management



Reference: GSMA, Digital Agriculture Maps, 2020

3.2. Data types and data flows in agricultural value chains

These technological advancements in the agriculture sector have resulted in large amounts of data (digital information that is stored in or used by a computer) being generated by farmers and other stakeholders throughout the value chains. Data is continually produced as individuals and businesses use machinery, farm management platforms, online marketplaces, storage and transport facilities, and other digital tools. Increased private sector involvement has also contributed to increased data generation and use[3] through, for example, for-profit agronomy and advisory services that rely on data to inform interventions and measure impact. Non-digital information such as handwritten records by farmers (e.g., paper-based farm logbooks) is not considered in the present report given the limited use cases for that type of information.

In the context of this report, we are especially interested in the data sovereignty of farmers and cooperatives; hence we focus on agricultural data, directly or indirectly related to farmers and their farms. Within that category of agricultural data, personal data is especially critical for data

sovereignty as its usage is usually more circumscribed by the regulatory frameworks in place.

Farm and farmer data is typically generated by farmers and agents, or through usage of digital systems and sensors. Farms and farmers are the main source of primary data, for example, demographic and socioeconomic household statistics, and information on agricultural output and farming practices. This data is shared directly via phone, surveys, or field interviews. Farmer data can also be collected in a secondary manner by extension agents or officers. At the tertiary level, data can also be generated semi- or fully-automatically by digital systems that farmers use e.g., logs of e-advisory solutions, or through remote or on-farm sensors that transmit information remotely.

Box 2. Definition of personal data

In the context of this study, we will use the definition of personal data from the 2021 Data Protection Act of Zambia, one of the most recent data regulations issued in a LMIC.

The act defines personal data as «data which relates to an individual who can be directly or indirectly identified from that data, which includes a name, an identification number, location data, an online identifier, or one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person».

Reference: National Assembly of Zambia, The Data Protection Act, 2021

Figure 3: Categorisation of farmer and farm data based on the origin of the data

	Collected by a farmer	Collected by an agent	Generated through usage	Generated through sensors
Description	Farmer collects his/her own data	Agent or extension officer collects data from a farmer or his/her farm	Farmer uses a digital solution which generates logs	Data is collected by sensors directly on the farm or remotely with drones/satellites
Example datapoints	• *With feature phone:* closest village to obtain more accurate weather forecasts • *With smartphone:* pictures of crops for pest and disease detection	• *With smartphone/tablet:* name, age, gender, and national ID • *With laptop:* quality & volume of production after harvest season during aggregation	User journey data from an e-extension service including identification of the contents consumed by the farmers, timestamps, locations, farmer IDs, etc.	• *With drones/satellites:* fields delineation • *With on-farm sensor:* soil temperature and humidity
Level of identifiability	◔	●	◕	◔
Level of farmer control	●	◕	◑	Remote sensors: ◔ On-farm sensors: ◕
Level of marketability	◔	●	◔	◕

Key: ◔ Low ◑ Medium-low ◕ Medium ● High

These categories of farmer and farm data have different levels of identifiability, farmer control, and marketability. Data collected by agents and extension officers are usually directly related to a farmer and their farm and are hence characterised by the highest level of identifiability or capacity to identify the farmer. When it comes to the level of farmer control, farmers are usually able to exercise stronger control over data that they collect themselves. Finally, in terms of marketability and tradability, from past experience we can identify a higher potential for the data directly collected by agents, closely followed by the data generated through sensors.

The ultimate use of these datasets varies, ranging from product development to communication and go-to-market strategies. The use can be categorised into three main groups being: (i) internal data uses where the data is not shared externally; (ii) by-product uses where the data is shared along a product or service transaction (commercial or non-commercial) but is not at the core of the transaction; and (iii) data transaction uses where the data is valued (commercially or non-commercially) at the core of a transaction.

Figure 4: Categorisation of farmer and farm data based on their use

	Data remaining internal	Data shared along a transaction	Data at the core of a transaction
Description	Data collected, generated, or accessed by an organisation and used for internal processes only, without direct or indirect commercialisation of the data	• Products or services bought or sold by an organisation and involving the sharing of personally identifiable data • The data is a by-product which is not at the core of the transaction and not directly monetised • Includes transaction between businesses and/or governments	• Data collected, generated, or accessed by an organisation and shared with another organisation for commercial or non-commercial purposes • The data is at the core of the transaction • Includes transactions between businesses and/or governments as well as between businesses and consumers
Example datapoints	• Customer Relationship Management Data (e.g., private farmer registry) managed in a fully internal CRM system for communication with cooperatives • Data history of transactions with farmers used for product design and development	• Bags of grains sold by an aggregator to an off-taker along with farmer data related to the bags • Agribusiness buying seeds from an input provider and sharing farmer data to assess quantity and nature of seeds	• **Non-commercial:** Agricultural statistics shared by the Ministry of Agriculture with the Ministry of Gender for program assessment • **Commercial:** Off-taker buying crops from an aggregator and paying a premium based on ESG traceability records

3.3. Impact implications of digitisation and data in agricultural value chains

The increasing generation of data via digital channels brings both social and economic benefits as well as inherent risks. If not adequately protected, data, particularly personal data, can be a tool for wielding harm. Efforts around cybersecurity have been crucial in preventing data breaches to protect individual and organisational data. Data ethics have also been key in introducing codes of conduct across the entire data lifecycle (how data is captured, handled, processed, shared, and used). In the agricultural sector, ethics also considers the fair repatriation of value that is created along agricultural value chains.

Recognising that data has inherent value and considering how stakeholders can benefit equitably is vital, with particular attention to be paid to the smallholder farmer as the main contributor in terms of value creation.

In agricultural value chains, smallholder farmers have typically had the least amount of agency over their data, which has implications for their privacy. Farmers need privacy protections to prevent harm, exclusion, or discrimination by third parties. By electing to not participate in certain data sharing efforts, farmers can prevent relational

imbalances between themselves and other stakeholders that would be to their financial detriment, as seen for example, in the use of data on productivity by suppliers or aggregators to set unfair prices for input or outputs. Other value chain stakeholders also face similar privacy risks; they would benefit from increased control over data to prevent the mining of their purchasing data, consumption preferences, and broader user profiles without their consent.

Empowering smallholder farmers to have more control over their data is also critical to the improvement and protection of their livelihoods. Farmers can benefit significantly from greater power symmetries in data control, with benefits such as: (i) preventing vendor lock-in; (ii) enabling better design of products and services along with their technical, business, and operational models; (iii) creating opportunities to add value in terms of direct income or in-kind value; (iv) accessing new data insights; and (v) hindering discrimination based on misuse of personal data[4].

Expanding data control for smallholder farmers is contingent upon certain enabling factors such as access, literacy, and awareness, which ultimately present further potential for impact. Most smallholder farmers in LMICs face technological and literacy barriers that limit their ability to exercise control over data. Key enablers for overcoming these barriers at the farmer level as well as those related to broader environment enabling misuse, such as a lack of regulation, must therefore be identified, assessed, and advanced. Helping farmers gain awareness of the different ways in which their data is being collected such as satellite imagery, geolocation data, social media records, credit transactions is one step. As is creating awareness as to how the data is used, for example to monitor crop yields, track consumer preferences, or sold for profit. Literacy efforts can also help farmers to better assess the quality of information and/or technology shared by market actors who generate value directly or indirectly from farmer and farm data (e.g., through international certifications, carbon credits, government subsidies, etc.).

More broadly, issues regarding data control are important in strengthening the foundation for robust data governance frameworks. Efforts to improve the control of data for farmers will push both the public and private sectors to think critically about the broader need for data governance in agricultural value chains – that is, the adherence of the agriculture data ecosystem to standards, processes, rules, and regulations. Ideally, momentum should originate from the public sector through top-down interventions aimed at strengthening the enabling environment and eventually calling and incentivising greater data sovereignty. Other ecosystem support actors such as development partners can also leverage the growing momentum and receptiveness around the topic of data governance to form strategic partnerships with private, public, and non-profit actors, and shape targeted interventions for greater data sovereignty[5].

Data sovereignty offers a way to ensure that smallholder farmers are empowered to have control over their data and thus contribute towards the fair digital transformation of agriculture. In this report, we will define the concept of data sovereignty, explore its key enablers and related business and impact opportunities, and outline interventions to foster it for smallholder farmers.

IV. INTRODUCTION TO DATA SOVEREIGNTY IN AGRICULTURE

4.1. Concept and definition of data sovereignty

There is no singular definition for data sovereignty applied in research; most definitions available reflect a common set of ideas around privacy, ownership, safeguarding, control, and regulation.

We define data sovereignty as the capability of an individual or an organisation to have control over their personal and business data. When it comes to control over data, we distinguish four types of activities, namely:

- Handling – data collection, processing (from storage to analysis), and sharing
- Consent – provision of consent for data collection, processing, and sharing
- Monitoring – data tracing and monitoring (i.e., identifying who is accessing what data at what time and for which purpose)
- Withdrawing – removal of access to the data or deletion of the data itself

This control is made possible by certain enablers at the individual and organisational level such as awareness, access, and literacy, as well as at the ecosystem level, such as the regulatory, digital, and business environment. We depict the relationship between these ideas in the framework below.

At both the individual and organisational level, there are three key principles underpinning the ability to exercise control over data:

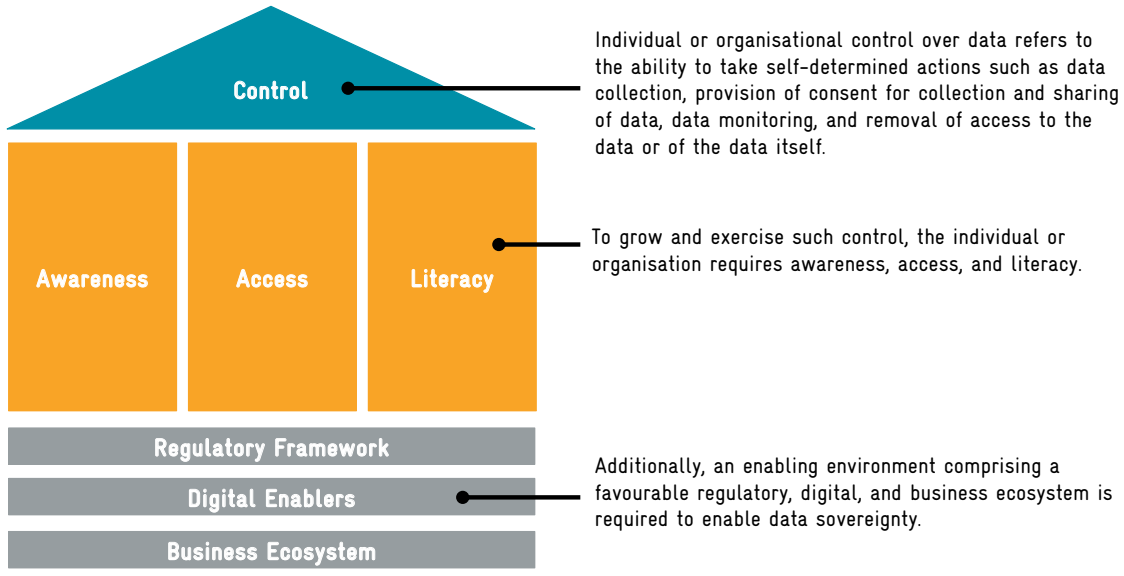
i. **Awareness:** The knowledge of the data's existence and the basic laws outlining one's rights regarding their data. In an ideal data sovereignty situation, awareness also speaks to the idea that an external stakeholder's access to and use of a user's data should occur with the explicit consent of the user to ensure his/her adequate awareness of the data's existence.

ii. **Access:** The ability to retrieve and examine the data itself as well as access to the tools and technology that enable one to control the data. It also includes protocols that enable a user to either allow or revoke access to the data.

iii. **Literacy:** An understanding of the data itself, i.e., of its nature and value, and of the digital tools and technology that enable control over the data. Thus, while awareness speaks to knowledge, literacy refers to the competence to identify and assess data's benefits, and to use the technologies that make the data accessible, interpretable, and sharable.

Figure 5: Data sovereignty framework

We define data sovereignty as the capability of an individual or an organisation to have control over their personal and business data. This is made possible by certain enablers at the individual and organisation level such as awareness, access, and literacy, and at the ecosystem level such as the regulatory, digital, and business environment.



Cutting across these principles but not necessarily conditional for control of data are a set of enabling factors that foster awareness, literacy, and access to data. These include:

iv. **Digital enablers:** Data is digital information and the control of it requires interaction with digital infrastructure and tools. Digital enablers include technologies that support access, literacy, and awareness. For example, digital identification (ID) technology allows users access to data for which they have been granted rights. Digital payments infrastructure enables data monetisation and sharing while internet connectivity such as mobile net works, domestic, and global clouds allow for unrestricted and remote access to data.

v. **Business ecosystem:** Looking at the commercial environment allows us to acknowledge the business realities and drivers of public and private organisations which are required to enable access, literacy, and awareness. Access to data, particularly remote access, is made possible through innovations such as data management software like digital registries that collect, organise, store, and avail static and dynamic data to various stakeholders, and mobile and USSD applications that can access these registries remotely. More broadly, the business and start-up market continues to be accelerated through business incubation services and venture financing, and by a high supply of human capital fuelled by fast-growing younger demographics in LMICs.
An enabling business ecosystem is also one where there are clear business and impact cases for data sovereignty. Otherwise, private enterprises may be dissuaded by the opportunity cost of shifting controlling rights, and in some ways democratising access to data, which may be seen to deplete its financial value.

vi. **Regulatory framework:** It is also important to consider the legal and policy frameworks under which data use and control is governed. By its very nature, regulation is jurisdictional; laws are designed to be enforced within specific international, regional, or local territories. Data regulation therefore means subjecting data and related activities to the respective laws of the country or region where the data is produced. This principle recognises that the region and country-specific regulatory context of data collection and sharing, both de jure (by law) and de facto (by fact or in practice), likely varies from one country to another. The treatment of data and data sovereignty, it follows, does as well.

As an example, the European Union (EU) is currently governed by the General Data Protection Regulation (GDPR), a regulation in EU law laying out data protection and privacy guidelines to create more consistent consumer and personal data collection for use across member countries[6]. However, individual EU member states have gone still further to delineate country-specific regulatory frameworks that reflect the GDPR within their own national context. In early 2021, the Federal Ministry of Economic Affairs and Energy in Germany (BMWi), for example, released the Digital Strategy 2025 outlining approaches to creating and enabling necessary infrastructures, regulatory frameworks, entrepreneurial skills, and capabilities, production capacity, and innovation financing to unlock the potential of digitisation, including data[7].

Complementary to the GDPR at the European level is the Data Governance Act (DGA), which more specifically seeks to facilitate and regulate data intermediaries – individuals, companies, researchers, and/or public agencies – to freely trade, circulate, and re-use data. The framework lays the groundwork for a working data economy or market in which trust is established and where both B2B (business-to-business) and B2C (business-to-customer) data sharing procedures and data transaction costs are more clearly outlined and greatly eased. Gaining the trust of stakeholders is critical; low trust between stakeholders due to competing commercial interests and technological gaps is currently a key barrier to data sharing and re-use. Additionally, trust is a primary driver for "data altruism," a concept introduced by the DGA based on data intermediaries leveraging shared data for the greater good e.g., community development[8].

Regulations also include the rights and ownership granted to individuals and organisations over data, that is, the legal property right. Ownership is not a prerequisite of control, however; an entity can exercise control over data that they do not own and individuals can be limited in their control over data that they create, since companies can still put in place levers that prevent or nullify any type of right at a later point (e.g., once the data enters a processor). This is where clear and robust data governance regulations at the local level come into play.

We see the data sovereignty framework above as having cross-sectoral relevance and as complementary to other frameworks, such as the CARE Principles for Indigenous Data Governance. CARE is a framework for data governance and sovereignty developed by the Global Indigenous Data Alliance (GIDA), an international network that aims to promote indigenous control of indigenous data.
The CARE principles advocate for indigenous data to have (i) **C**ollective benefit, that data ecosystems are designed and function in a way that allow indigenous peoples to derive benefit from it, (ii) **A**uthority to control the data, (iii) **R**esponsibility imposed on those working with indigenous groups to share how their data is being used to their collective benefit, and (iv) **E**thics as a primary concern across all stages of the data life cycle and across data ecosystem[9].
Under the second principle – "authority to control the data" – our data sovereignty framework can be used to expand upon and contextualise the precise ways in which control is exercised.

Box 3. DigiMe as a practical application of data sovereignty principles

DigiMe is a mobile solution that allows users the ability to give consent for the access to their data by third parties. Once consent is provided, the user has full transparency over who has access, what data they have access to, which time periods they access the data, and for what purpose. In other words, users are given control over their data.

Data is encrypted in the DigiMe platform and only made accessible once consent is granted and the user is logged in. Since all operations happen in a temporary virtual personal cloud that terminates once done, the third party cannot transfer or store the data for future use. Additionally, because consent and access are explicitly shared, they can also be revoked, giving the user control over potential misuses of their data».

Reference: DigiMe (https://digi.me/, visited December 2021)

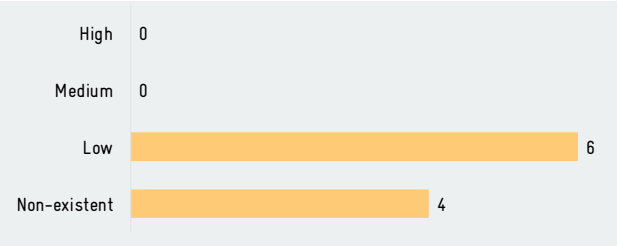
4.2. Current state of data sovereignty in agricultural value chains in LMICs

In assessing the state of data sovereignty in agriculture, the reality on the ground is far from ideal. We interviewed about 20 key industry stakeholders (*see Stakeholder interview list in* Appendices) a**nd asked 10 of them to assess the key enablers of control among smallholder farming communities. Overall, stakeholders ranked the enablers and therefore the level of control exercised as low.** Stakeholders included data governance experts, digital service providers, and development actors, all with a deep understanding of the role of data in agricultural value chains. The bar graphs below show the results of the survey on a scale of 1 (non-existent) to 4 (inappropriately strong).

Individual or organisational enablers

I. ACCESS
Most industry stakeholders rank smallholder farmers' access to their data as low, with 4 out of 10 citing non-existent data access.

Figure 6: Industry ranking of data access levels among smallholder farmers



A key driver of data access is access to mobile technology, which remains relatively low in rural areas across LMICs due to low purchasing power. Most data-related applications are accessed remotely by smallholder farmers in rural areas using mobile phone applications. In most LMIC regions, the number of mobile subscribers has surpassed 50% of the total population, excluding Sub-Saharan Africa, which stands at 46% of the region's population[10]. However, most mobile subscribers in LMICs remain concentrated in urban areas due to the prevailing challenges of extending mobile infrastructure to rural and remote areas, such as high rollout costs and low returns[11].

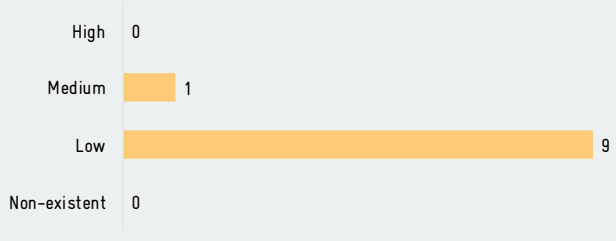
This leaves many smallholder farmers without access. Gender gaps also exist across LMICs; on average, women are 8% less likely than men to own a phone. This gap is especially wide in South Asia and Sub-Saharan Africa, where the gender differences in mobile ownership are 23% and 13%, respectively. The average gender gap also jumps from 8% to 20% for smartphone ownership specifically[12].

Handset affordability is the number one barrier to mobile ownership in many LMICs and many of the households in extreme poverty in LMICs are agricultural households; phone prices are, however, falling rapidly. FAO data shows that 76% of the rural extreme poor workers globally aged 15 and above work in the agriculture sector as a primary activity, either doing on-farm work or agricultural wage employment[13]. The average cost of an entry-level, internet-enabled device continues to decrease however, dropping from 44% of monthly income in 2018 to 34% in 2019. This is driven by the increasing availability across Southeast Asia and Sub-Saharan Africa of low-cost phones with smart features[14].

II. AWARENESS

The vast majority of our expert interviews rank awareness among smallholder farmer communities as low.

Figure 7: Industry ranking of data awareness levels among smallholder farmers

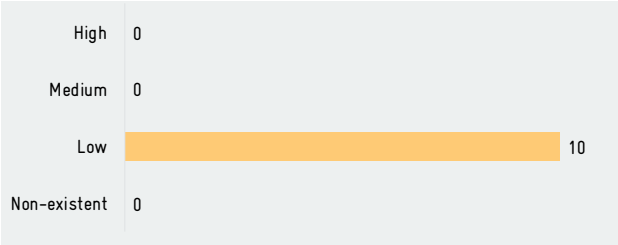


Farmers' awareness of the existence and use of their data as well as their rights regarding their data is difficult to objectively measure. Estimates about the awareness of mobile internet capabilities in LMICs prove an insightful proxy in this context. While access rates of mobile technology report strong and growing figures, users in LMICs are still buil-ding awareness of mobile internet capabilities. Nearly one quarter (25%) of adults across LMICs remain unaware of mobile internet services, with rural populations and women lagging most[15].

III. LITERACY

Every industry stakeholder interviewed ranks data and digital literacy levels among smallholder farmers as low.

Figure 8: Industry ranking of data and digital literacy levels among smallholder farmers



Data and digital literacy are identified as one of the key constraints to reaching the potential of digital solutions in the agriculture value chains. CTA survey responses from 175 distinct digitisation for agriculture (D4Ag) enterprises across Africa showed that almost 30% of agri-tech providers view consumer-level barriers such as digital literacy as one of the top three challenges to the adoption and use of digital solutions[16]. Low digital literacy levels among smallholder farmers constrain not only their ability to leverage technology and data but also the potential reach of the digital tools required to enable the exercising control over the data. Gender disparities in basic literacy or education also have a spill-over effect, translating into financial and digital illiteracy.

Ecosystem enablers

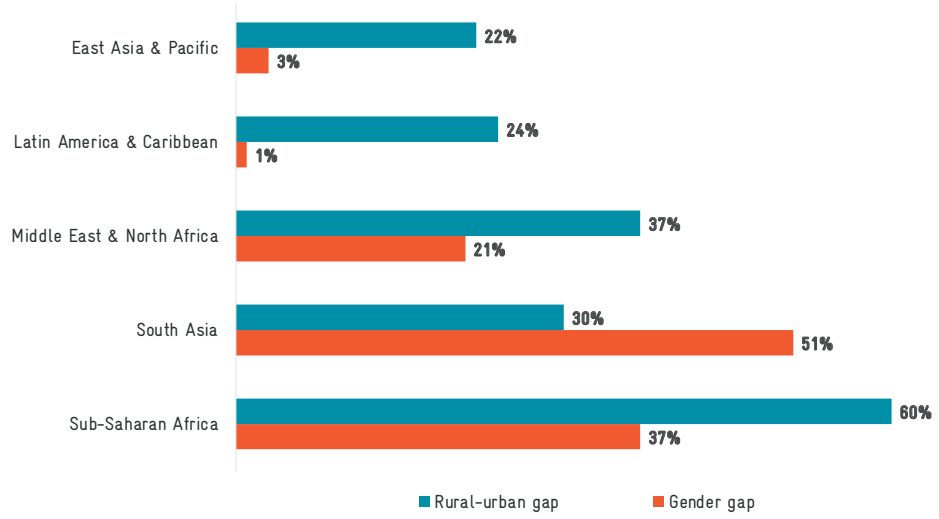
Gaps in the state of enabling factors at the ecosystem level, such as digital enablers, and the business and regulatory environments across LMICs are also outstanding.

I. DIGITAL ENABLERS

The main digital enabler when it comes to data sovereignty is the availability of internet connectivity, which continues to penetrate across various income segments in LMICs. In 2019, 82% of the population in LMICs were covered by 4G. This is a result of expanding network infrastructure and more affordable mobile data. The cost of 1GB of data as a share of monthly GDP per capita has decreased by more than 40% in LMICs since 2016[17]. Regionally, Sub-Saharan Africa and South Asia host the most of the world's uncovered population – 67% as of 2019.
At 25%, Sub-Saharan Africa has the largest coverage gap, while South Asia has the largest usage gap of 61%[18].

People living in rural areas across LMICs such as smallholder farmers, however, are 37% less likely to use mobile internet than those living in urban areas, with prevailing gender disparities. On average, women in LMICs are 20% less likely to use mobile internet than men; an estimated 300 million fewer women are using internet services[19].

Figure 9: Rural-urban and gender gaps in mobile internet use across LMICs (Source: GSMA, 2020)



Many smallholder farmers operate entirely offline and off-grid, relying on simple farming tools and technologies to drive outputs. While various interventions are progressively looping farmers into digital ecosystems, such as digitally enabled, pay-as-you-go (PAYGo) solar-powered devices, the pace of inclusion is not yet keeping up with the enabling environment needed for data sovereignty across value chains in rural areas. Even where technology has penetrated, the costs of accessing mobile phones or data technologies remains prohibitive for most smallholder farmers. This shows the need to address these issues in tandem.

II. BUSINESS ECOSYSTEM

Investment in agri-tech solutions is limited and key decision-makers in local business ecosystems (e.g., investors, business leaders, and other advisory partners) within LMICs are not yet prioritising data sovereignty for smallholder farmers. Investors and technical assistance partners such as business accelerators and incubators could wield influence in setting the mandate for digital infrastructure and other solutions that enable access, literacy, and awareness over data for farmers. However, this is not the case. Agri-enterprises continue to collect both individual and aggregated data e.g., from producer cooperatives, such as sale volumes data, crop verification data, and credit and insurance data from farmers, with or without their consent or fair compensation. Transactions and therefore governance occurs primarily between organisations[20]. This translates into low institutional trust among farmers, which ultimately limits their engagement and constrains data-sharing arrangements with ecosystem actors.

Competing commercial interests as well as legal and technical constraints within the business ecosystem also limit the involvement of smallholder farmers in exercising control over data. Some providers may be hesitant to expand data access rights for farmers due to the risk of losing access to the data themselves or of lowering its financial value. Beyond commercial drivers, there are also legal and technical aspects. For example, farmers often have limited data portability, that is, the flexibility to transfer their data from one service provider to another, or to simply retrieve it for their own private use. Legally, some data-sharing arrangements lock farmers into contracts with a specific digital service provider that prevents them from sharing historical data with other providers[21]. In some cases, providers are not necessarily averse to farmers sharing their data but the data architecture to do so is not in place. This would require both providers having the same or similar management information system (MIS), data libraries, and other compatible infrastructure. The issue of data portability also creates more work for farmers, with them repeatedly sharing the same data through multiple surveys and applications, as opposed to building a reusable, cumulative data history[22].

III. REGULATORY FRAMEWORK

While the GDPR and related national policy offshoots such as Germany's Digital Strategy 2025 have addressed important issues relating to personal data, agricultural data often falls beyond the scope of personal data. This leaves minimal specific regulations governing the fair use of agricultural data[23] and in LMICs, even such broad state or regional frameworks are often lacking. There are some ongoing efforts in the EU, such as COPA-COGECA's Code of Conduct, that aim to codify standards around agricultural data sharing by contractual agreement. Specifically, the codes outline definitions for roles and processes in data sharing with the aim of protecting the sovereignty of the data originator. COPA-COGECA is a union of two agricultural producer organisations – COPA and COGECA – that represent the interests of over 13 million farmers and 22,000 agricultural cooperatives across Europe[24].

Most LMIC countries lack laws to protect sensitive and private information at its geographic location, that is, at the point of its production. In many countries, once the information crosses national borders, it is no longer subject to local jurisdictional laws. This allows international entities to profit from smallholder data without their consent. Additionally, the lines between personally identifiable data (e.g., nationality, age, marital status, occupation, expression of opinion, etc.), and non-personal data in the agriculture sector remain blurred. This is especially true in the context of smallholder farming, where primary demographic and socioeconomic data at the household level is often collected alongside farm and productivity data. Data collectors are therefore not adequately distinguishing between private and public data, and the lack of guiding laws makes it difficult for farmers to claim ownership and control over the data.

A global 2020 World Bank survey of 60 countries shows that while ~80% of high-income countries already have laws safeguarding personal data in place, including key rights granted to individuals over their data that create a social contract with which third parties must comply, only 40% of low-income countries and 53% of lower-middle-income countries have done the same. Additionally, only 30% of low-income countries and 40% of lower-middle-income countries have an established data protection authority[25]. This points to the gap between policy and enforcement; while some LMICs have data protection laws on paper, only a few have the responsive mechanisms or institutions in place to implement and enforce them.

The prevailing gaps across these enablers of data sovereignty cause information and power asymmetries in the data-sharing arrangements between farmers and service providers. Consequently, with agricultural data under the control of a relatively small pocket of stakeholders, its benefits become skewed in favour of those who gather, access, and use it. Stakeholders with insights into trends in crop yields, crop shortages, crop prices, and so on, wield an unfair advantage over the producers creating that data at the farm or farmer-level.

Box 4. Regulation of data privacy and protection in Uganda

Within the last three years, Uganda has passed the Data Protection and Privacy Act, 2019, and the Data Protection and Privacy Regulations, 2021, the latter of which are intended to enforce the former. Both policies aim to regulate and enforce the already constitutionally protected right to privacy for Ugandan citizens and residents within and outside of the country, specifically the privacy of personal data in its collection, processing, and disclosure [1].

However, between the passing of the Act in March 2019 and the Regulations in May 2021, there seem to have been gaps in the observation of the guidelines under the Act. For example, a centralised national cloud data centre was launched in July 2019 in Jinja District to serve all government agencies and departments. Using this system, interagency data transfers on personal citizen information may occur without their knowledge, which would fall short of the Data Act guidelines [2].

Some public bodies also continue to use certain types of personal data without much oversight or review. For example, the Uganda Police Force announced plans to integrate sensitive personal data from the National ID and immigration data systems with CCTV forensic systems [3], but critics highlight that there is no clear outline of how data would be protected.

To put the data regulations into effect, a Data Protection Office was established under the National Information Technology Authority of Uganda (NITA-U), an autonomous government parastatal under the Ministry of ICT. The Office is faced with the task of enforcing compliance with the privacy regulations across many disconnected public agencies while ensuring interoperability and effective data sharing [4].

References:

[1] Ministry of ICT & National Guidance, Data Protection and Privacy Act 2019; Ministry of ICT & National Guidance, Data Protection and Privacy Regulation 2020

[2] Daily Monitor, Museveni launches Shs43b data centre in Jinja, 2019

[3] Privacy International, One year on, what has Uganda's Data Protection Law changed?, 2020

[4] Personal Data Protection Office (https://www.pdpo.go.ug/, visited in November 2021)

IV. CROSS-CUTTING CONSIDERATIONS

Enabling data sovereignty for smallholder farmers should be a goal within a greater context or with an end in mind; for the market to be sufficiently incentivised to adopt data sovereignty goals, there needs to be a clear and attractive market for the data. Market demand for data follows basic economic principles, that is, it will increase or decrease based on: (i) the level of good faith with which stakeholders operate in sharing and reusing the data, (ii) the technological advancements that allow for easier data transfer, and (iii) in the presence of useful laws or guidelines in place.

The public sector therefore plays a key role in enabling the emergence of a data market, such as the steps taken by the EU through the Data Governance Act. However, it is the private sector that is the engine for growth and innovation. For example, if smallholder farmers have greater sovereignty over their aggregated data, it can only be commercialised via technical platforms and within a digitally enabled environment, which allows them to trade with the market. Increased fairness in data control is therefore only as powerful as the ecosystem's potential to unlock value from that data.

V. MARKET GAPS AND OPPORTUNITIES AROUND DATA SOVEREIGNTY

5.1. Risks and missed opportunities related to low data sovereignty

As outlined in the previous section, the level of LMICs farmers' data sovereignty is low. Yet farmers, as the principal producers of value in the sector, are well-positioned to use data and generated insights to make decisions that inform greater value creation within agricultural value chains. Farmers continually innovate within the sector and make informed decisions based on tried and tested approaches, inherited knowledge, direct encounters with market, ecological, and climate changes, and information exchange with other farmers.

Excluding the principal creators of value from conversations and activities around their data only creates gaps in data insights and solutions.

Given the important role that data sovereignty plays in impacting smallholder farmers and agricultural value chains, and the outlined gaps and challenges that prevail, it is worth considering the risks or opportunity cost of continuing the status quo. These risks are summarised in the figure below.

Figure 9: Risks and missed opportunities of low data sovereignty in agriculture

	Fairness	Design	Competition	Discrimination
Description	Farmers' lack of control over their data leads to unfair and unsustainable redistribution of benefits and wealth generated along the value chain	Farmers' lack of control over their data leads to limited data availability and accessibility to drive and improve the design of rural products and services for farmers	Farmers' lack of control over their data limits farmers' choices over existing products and services and broader competition in the market	Farmers' lack of control over their data leads to personally identifiable information breaches and misuses
Example	Farmer not getting a share of the premium paid by a consumer for a more sustainably grown vegetable	Farmer insurance not adapted to female farmers due to poor data leading to biased design	Farmer community stuck with one input provider owning their production data history	Farmer is refused access to a financial product based on their racial status

5.2. Building data sovereignty in agricultural value chains

Keeping the risks and missed opportunities related to low data sovereignty in mind, there are three types of interventions aimed at building data sovereignty into agricultural value chains: indirect, intermediary, and direct interventions. These types of interventions are not mutually exclusive and can be sequential — that is, with indirect interventions better suited to less mature contexts and direct interventions more adapted to geographies and value chains with higher levels of digitisation.

Indirect interventions: strengthening the enabling environment and the capacity of farmers

Indirect interventions do not directly lead to farmers or organisations gaining more control over their data. Theses interventions include programmes, projects, services, products, or even law and regulations aimed at strengthening the enabling environment and/or the capacity of farmers. Following the six pillars of our data sovereignty framework, these interventions can lead to:

i. **An increased awareness** of farmers and their associations over the existence of their personal data as well as the rights they can exercise over that data (e.g., awareness campaigns deployed through networks of extension officers)

ii. **Stronger access** to the tools and technology that enable farmers and their associations to exercise control over their data (e.g., programmes promoting the digitisation of farmers associations supported by the public sector)

iii. **Greater data and digital literacy** ensuring farmers and their associations have a better understanding of the data itself, the potential benefit they could get from it, as well as the tools they can use to exercise control over the data (e.g., TVET programmes designed for extension officers and farmer leads focusing on usage of digital agriculture solutions)

iv. **More advanced digital enablers** facilitating the strengthening of awareness, access, and literacy (e.g., launching of a new national digital ID)

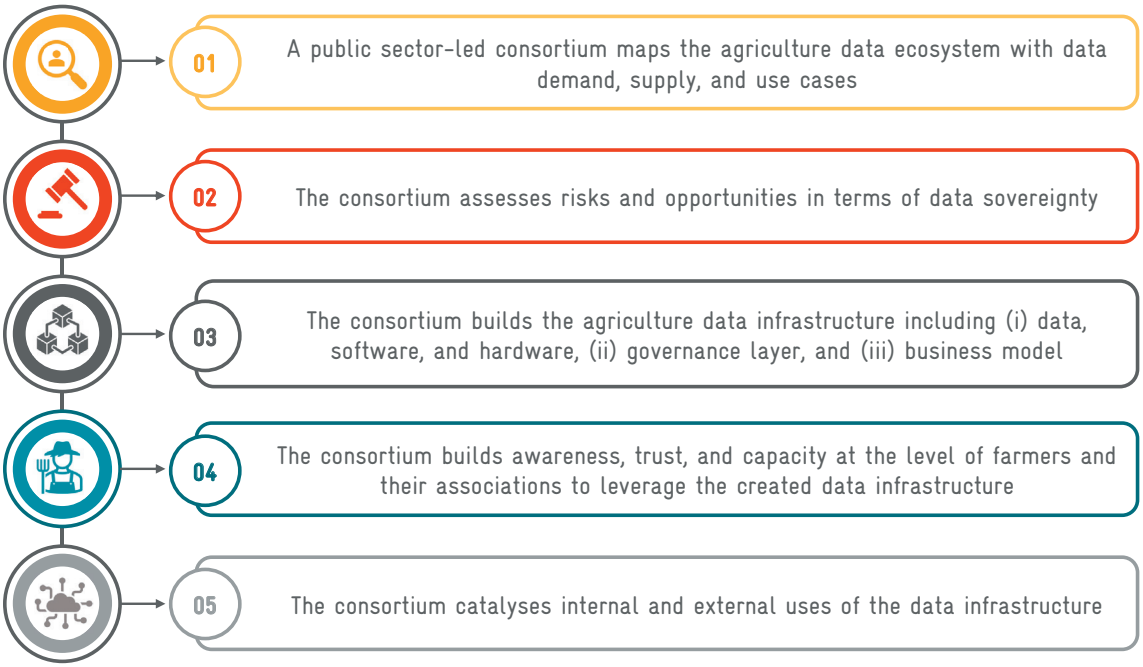
v. **A more mature business ecosystem** facilitating the ease of private and public stakeholders who are part of the broader digital ecosystem to do business (e.g., creation of an incubator for AgTech start-ups)

vi. **A stronger regulatory framework** which ensures the use and control of the data is governed efficiently, securely, and ethically (e.g., formulation of a data privacy and protection act and establishment of a regulatory body mandated to enforce it)

Intermediary interventions: establishing the foundational layer of a data sovereignty platform with the public sector

Intermediary interventions are more direct but still require investment from the public sector to build a foundational sovereignty platform or data ecosystem. These types of interventions typically take place in a context where the penetration of digital agriculture solutions (e.g., e-advisory solutions) is low and agricultural value chains are still at the onset of their digitisation. Here, advancement of data sovereignty is a top-down effort, initiated at the national level and driven by the public sector, and gradually looping in technical intermediaries from the private sector, farmers and farmer associations, and the broader ecosystem of actors. The figure below summarises the 5 key steps involved.

Figure 9: Risks and missed opportunities of low data sovereignty in agriculture



STEP 1 – As a first step, the government – usually with a consortium of technical and development partners – plays the critical role of mapping the existing digital agriculture ecosystem and identifying the relevant use cases for data in the targeted agricultural value chains (e.g., data on farming practices for carbon sequestration certification in the Brazilian timber value chain). This part of the exercise should clearly identify (i) both the supply side and demand side of agriculture data along with their needs and challenges, and (ii) the purpose of the data and the way it will be used, generating enough impact and/or value to sustain the use case.

STEP 2 – Based on these use cases, the public sector-led consortium assesses the risks and opportunities for data sovereignty, especially when it comes to farmers' control over their data. This assessment should consider the whole data value chain and identify risks and opportunities for control from (i) data collection or generation, to (ii) storage, cleaning, and processing, to (iii) reuse and sharing. Additionally, different levels of control should be examined including (i) simple monitoring of the data, (ii) consent management throughout the data value chain, (iii) self-management of the data itself from collection to sharing or deletion.

Box 5. Definition of use cases

In this section of the present report, two types of use cases are defined:

- **Data use cases** – correspond to a description of the ways in which stakeholders of an agricultural value chain use a data point or dataset for a clear purpose along the data value chain (e.g., an agent measures the size of a farm through a mobile application to help a farmer subscribe to a subsidy programme)

- **Data control use cases** – subset of the data use cases, data control use cases correspond to a description of the ways in which stakeholders exercise control over their data for a clear purpose (e.g., a farmer provides consent to an agribusiness to share his data with a bank to access a loan)

STEP 3 – With clear identification of the data use cases and risks and opportunities for data sovereignty, the consortium starts building the data infrastructure required to enable the fit-for-purpose and sovereign uses of data. The data infrastructure includes mostly (i) the data itself along with the hardware and software required to manage it (e.g., data dictionary, user-facing data management system controlled by farmers or associations, data lineage system, integration of national IDs, etc.); (ii) the data governance layer defining roles and responsibilities, standards, as well as policies, rules, and processes; and (iii) the business model or path to sustainability of the data infrastructure. An example of a public sector-driven initiative is a state-wide data registry of farmers that captures static (unchanging) and/or dynamic data on each farmer. This step is contingent on acknowledgment and buy-in from key government stakeholders on the demand for data within and beyond state borders.

Box 6. Governance considerations when building data sovereignty

In the context of agricultural value chains in LMICs, identifying the right entities to (i) maintain and scale the data infrastructure and (ii) exercise the control over the data, is critical to ensuring sustainability as well as an appropriate level of trust, awareness, and capacity. As mentioned previously, there are different governance structure options, including data cooperatives, research institutes, farmers unions or associations, national or regional governmental organisations, or even trusted private sector partners.

Identifying the right governance structure is at the core of the third step of the broader process described in this section of the report.

STEP 4 – Subsequently, the government undertakes a mass sensitisation effort using extension workers to build awareness, trust, and capacity among farmers so that they may leverage the created data infrastructure and exercise control over their data. Ideally this outreach builds on networks of grassroots structures such as producer groups, savings and credit cooperative organisations (SACCOs), village savings and loan associations (VSLAs), women's groups, and others. Such associations offer a manageable level of engagement as the government can reach millions of farmers through a few hundred or thousand touchpoints. The associations can also assume longer-term responsibilities around educating their members on their data and data rights, and onboarding new members onto the data infrastructure so that it can be maintained and expanded over time.

STEP 5 – Finally, after undertaking an appropriate level of engagement with farmers, their associations, key public institutions, and financial and technical partners, the leading consortium facilitate the deployment of the data infrastructure. While the data infrastructure is more likely to be leveraged first for internal use cases (e.g., associations of farmers using it to foster the sharing of data between members of the association), in more mature contexts, third parties – from both the data supply and demand sides – might start to engage with the data infrastructure (e.g., an association sharing its registry of medium-scale maize farmers with an input provider).

Direct interventions: enabling usability and sharing of data with the private sector

Direct interventions do not require building a foundational layer of data sovereignty as they take place in contexts where there is already a certain level of digitisation within the agricultural value chains. Farmers already access services like digital advisory, data-driven financial access, and smart farming. They might also be digitally connected to markets and other value chains actors – including associations of farmers – who might use supply chain management solutions including enterprise resource planning solutions (ERP) and customer relationship management systems (CRM). Given this level of digitisation, a large amount of data is already generated and theoretically available, though most likely not yet accessible, interoperable, or shared back with farmers or with third parties.

Within that context, direct interventions take a similar form as intermediary interventions (see previous section) with some important differences:

- **Public sector involvement** – The public sector is less involved, as most of the data ecosystem is already led by digitised and data-driven agribusi-nesses and rural service providers. In contrast, the data holders must be engaged early on to assess the demand side and supply side of data and identify fit-for-purpose data use cases and governance models.
- **Data standards** – There is a stronger need to define data standards to foster data interoperability such as data glossary, dictionary, and ontology.
- **Data portability** – There is also a stronger need to advocate for data portability to ensure that the data currently stored and managed by the different data holders (e.g., agribusinesses and service providers) can eventually be shared with the farmers, their associations, or third parties. This requires the appropriate regulatory framework and enforcement authority.
- **Internal use cases first** – As there is already a significant amount of data available that farmers are probably not aware of or of which the value is not well identified, direct interventions may want to start with data use cases where the data is simply shared back with the farmers or their associations to demonstrate its potential and incentivise them to become more data-driven.
- **Control focus** – While intermediary interventions have a stronger focus on the building of a foundation database and surfacing of data use cases, direct interventions – for the same budget – can allocate more resources to the identification of risks, opportunities, and use cases in terms of data control along the data value chain.

5.3. Value addition data use cases for farmers

Key to mobilising efforts around the challenge of data sovereignty is emphasising the appropriate incentives and helping farmers identify the potential value of their data. It is important to understand and build consensus around the potential economic and social outcomes of enabling data sovereignty for key individual and organisational stakeholders. The following use cases can offer incentives to farmers to digitalise and exercise more control over their data.

I. Direct Income: farmers see a direct impact on their income from the data

a. **Data transactions:** In a few cases, farmers can sell their data directly to buyers or via digital marketplaces. For digitally literate farmers, data can be disaggregated to be sold in discrete categories as opposed to entire data sets, e.g., data on farming outputs or productivity can be sold to specific actors. However, the marginal value of an individual smallholder farmer's data, who cultivates ~2–5 acres of land, may not be much – likely under one US dollar or even net negative after transactions costs – and therefore diminish their bargaining power[26]. Transactions of aggregated data present higher potential to generate direct income.

b. **Price premiums:** Farmers can use their data to make visible and verifiable any sustainable farming practices that meet environmental, social, and governance (ESG) standards, and which attract price premiums from responsible consumers. This can be enabled by technologies like blockchain, which allow for traceability and smart contracting functionalities that let consumers know where their food comes from and how it was produced[27].

c. **Carbon markets:** Carbon credit programmes as part of climate-smart agriculture (CSA) efforts can also offer data-driven revenue opportunities for farmers. Farmers can demonstrate a carbon sequestration or a reduced carbon footprint by enabling the collection and sharing of relevant data points on their farm and farming practices and by selling carbon credits[28].

II. In-kind Value: farmers exchange their data for a non-monetary benefit

a. **Data-for-services:** Data that farmers generate can be used as an in-kind payment for various agronomy and extension services. Farmers can share their data in exchange for knowledge e.g., data-driven tips to improve farming practices based on historical agricultural performance, training or technical assistance, participation in public and donor programmes, and so on. This includes use cases such as peer-to-peer advisory that make use of data to discover "peer" farmers to get in contact with for advisory and exchange (e.g., WeFarm).

b. **Better-designed products and services:** Farmers are beneficiaries of hundreds of programmes, products, and services from the private, public, and donor sectors, all of which aim to be data-driven. Product and service providers need data to monitor product performance and for continuous improvement of their services. For the large part, smallholder farmers in LMICs share their data willingly with various partners, even when there is no immediate benefit[29]. However, farmers may not always be privy to how that data will inform an eventual outcome. Examples include machinery data used for real-time optimisation of performances, financial data integrated in estimation of credit scores, irrigation scheduling based on soil data, and so on[30].

c. **More informed public policy:** Data from farmers is a critical input not just for policy design but also for policy monitoring and evaluation, as evidence for governments to assess the effectiveness of local agri-food regulations in increasing productivity among farmers, enabling adaptation to climate change, and improving resilience across the population to potential market shocks, including food shortages[31].

Box 7. Examples of value addition data use cases for farmers

The Vietnam Farmer's Union (VNFU) is developing a data platform with the objective of enabling farmers to collect and share their data to make informed decisions about farming practices [1]. VNFU farmers recognize the value of data but struggle to quantify it and want the value to be generated in a transparent way. VNFU is already taking steps to build its farmers' capacity to leverage data solutions, for example, delivering a pilot programme in digital skills training to at least 30,000 farmers in partnership with Google [2]. More broadly, VNFU is working closely with the Vietnamese Ministry of Agriculture to designing a digital agriculture ecosystem, including the integration of emerging technologies like AI and blockchain, and other aspects of interoperability and the quality, governance, standards, and privacy of data [3].
The Farmer Business Network (FBN) is a US-based farmer cooperative that fosters the sharing of agricultural data between member farmers, operating as some form of a data cooperative. The data collected is currently used primarily for internal purposes but has potential to serve external use cases. However, the network has been able to commercialise the aggregated data; using a data and analytics platform that offers insight into pricing, marketing, and other supply chain concerns, FBN cuts out most middlemen, thus eliminating many middle layers of costs and increasing profits for its farmers [4].

References:
[1] Dalberg stakeholder interview, December 2021
[2] Geopolitical Monitor, Background: Agriculture 4.0 in Vietnam, June 2020
[3] OpenGov Asia, Vietnam Looking to Boost Digitisation in Agriculture, December 2021
[4] Farmers Business Network (https://www.fbn.com, visited December 2021)

5.4. Data sovereignty models

In addition to understanding the paths to build data sovereignty (see section 5.2) and the potential value addition data use cases for farmers (see section 5.3), it is equally important to understand how to operationalise data sovereignty mechanisms sustainably and at scale. This pertains to how smallholder farmers' personal data would be collected, accessed, controlled, shared, and used between and across stakeholders.

The high demand for individual control, security, transparency, and reusability suggests the need for personal data stores (PDS) controlled by farmers or associations of farmers. Such PDS are connected to the different systems which are generating, storing, and processing personal data from the farmers (e.g., ERP systems of agribusinesses). Depending on the context and their level of sophistication, PDS are used by farmers or data cooperatives to exercise different levels of control, from the provision of consent to the monitoring of who is accessing their data, at what point, and for what purpose. It is important to note that for an effective deployment, PDS require, among other things:

Box 8. Definition of PDS

While in some works PDS represents a very precise type of technology – usually decentralised – offering a defined set of functionalities, in the context of this report, the term personal data store is used to refer to a digital technology enabling farmers and associations of farmers to exercise any type of control over their data (ranging from simple listing to storage, aggregation, analysis, sharing, and permissions granting).

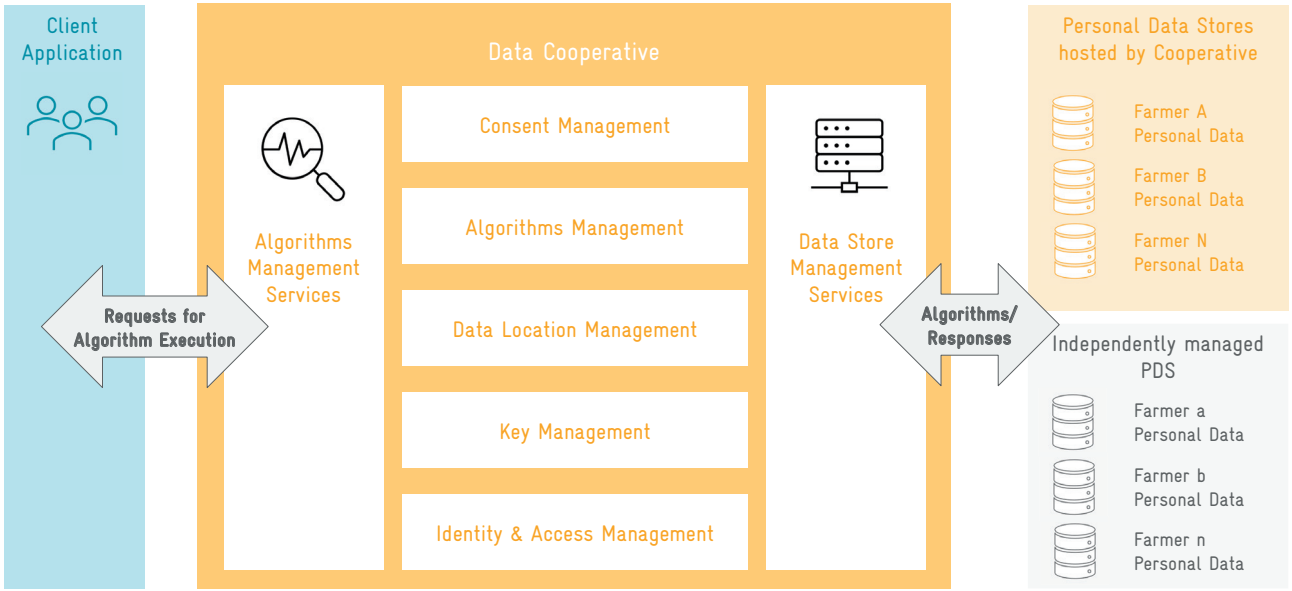
- to be supplied with machine readable data calling for data **portability**
- a certain level of **interoperability** and reusability of the data
- the **capacity** to operate the PDS
- the appropriate level of **trust** in the organisations involved in the development and management of the PDS and in the PDS itself
- the **incentives** to ensure integration and adoption of the PDS from both the supply side and demand side of data

Box 9. Definition of data cooperative

In the context of this report, we follow the definition of data cooperative from Hardjono and Pentland who define it as an organisation with fiduciary obligations to members that provides a promising direction for the empowerment of individuals through their own personal data. In agricultural value chains, a data cooperative can be an association of farmers (e.g., a farmer cooperative or union) but can also be an institution more independent of the community of farmers it serves (e.g., a national research institute).

These elements are usually missing in agricultural value chains in LMICs. Implementing the data sovereignty models presented in this section of the report may first require indirect, intermediary, or direct interventions (see section 5.2). While these data sovereignty models are being tested in other geographies and other sectors, they still have not been implemented at scale in agricultural value chains in LMICs. However, the experts engaged during the stakeholder interview process have confirmed that these models well represent the direction that the market is taking when it comes to farmers' data sovereignty.

Figure 10: Overview of the Data Cooperative Ecosystem[32]



Data Sovereignty Silo

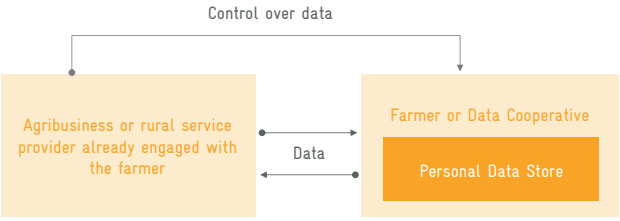
OPERATIONAL MODEL

In the context of the **Data Sovereignty Silo**, stakeholders push for more data sovereignty to further embrace their ethical values and/or to comply with new standards and regulations. Stakeholders pushing for data sovereignty can include the farmers themselves, their cooperatives, the regulatory bodies, and/or the service providers or agribusinesses. With the **Data Sovereignty Silo**, the personal data remained siloed and is not exchanged with third parties.

To exercise more control over his/her data, a farmer uses the PDS which is integrated with the data systems from the agribusiness or rural service provider already engaged with the farmer or a group of farmers. The data management of the PDS can be handled by the farmers themselves or a data cooperative.

An example of **Data Sovereignty Silo** is an agribusiness receiving finance or subsidies if it complies with new data standards including obtaining consent from farmers for the processing of their personal data.

Figure 13: Operational model of the Data Sovereignty Silo



POTENTIAL INCENTIVES

- **Farmer:**
  - exercising more control over his/her data
  - obtaining insights from the data generated by/with the agribusiness or service provider
- **Agribusiness or rural service provider:**
  - further embracing ethical values
  - complying with new standards or regulations (e.g., ESG standards from a partner, national data protection laws, etc.) which can potentially lead to subsidies or financing

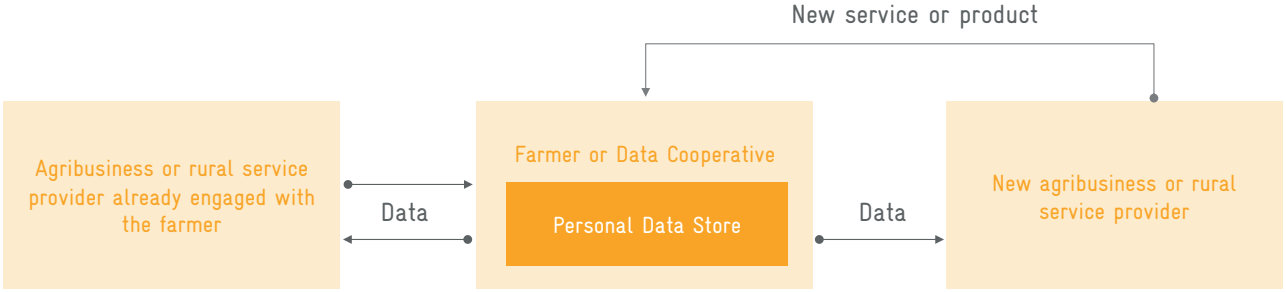
POTENTIAL BUSINESS MODELS FOR THE PDS

- **Subscription-based:** agribusiness or rural service provider pays a subscription to the organisation developing, deploying, and maintaining the PDS infrastructure

BARRIERS TO SCALE AND ADOPTION

- Low capacity of farmers to use the PDS to exercise control
- Low capacity of farmers or data cooperatives to generate actionable insights from the data available from the PDS
- Lack of incentives from the farmers to exercise control for the sake of it
- Integrability between the data system of the agribusiness or rural service provider and the PDS
- Lack of financing for the data cooperatives [specific to the case where the PDS is managed by a data cooperative]
- Low trust in the data cooperatives managing the PDS for farmers [specific to the case where the PDS is managed by a data cooperative]
- Readiness to pay for the deployment and maintenance of the PDS infrastructure

Figure 14: Operational model of the 1-to-1 Data Sharing



1-to-1 Data Sharing

OPERATIONAL MODEL

In the context of **1-to-1 Data Sharing**, farmers want to access new services or products requiring their data which has already been collected or generated by an organisation.

To access the new services or products, farmers use their PDS to open access to the existing data to an organisation offering the desired products or services. Upstream, the organisation having generated or collected the required data integrates with farmers' PDS to enable data sharing.

The data sharing and management of the PDS can be handled by the farmers themselves or a data cooperative.

An example of **1-to-1 Data Sharing** is when a farmer uses the data collected by his/her input provider to access precision agriculture services which require data points such as location, type of soil, type of inputs used, etc.

POTENTIAL INCENTIVES

- **Farmer:**
  - exercises more control over his/her data
  - obtains insights from the data generated by/with the agribusiness or service provider
  - accesses new services and products
- **Organisation offering the new service or product:**
  - expansion of customer base
  - reduces risks and costs related to customer acquisition
  - improves service delivery and customer experience
- **Organisation providing the data:**
  - maintains its relationship with the farmer
  - eventually benefits from the new services or products provided to the farmer

POTENTIAL BUSINESS MODELS FOR THE PDS

- **Transaction-based:** a transaction fee is paid by the new agribusiness or rural service provider for each data transfer from and/or to the PDS
- **Freemium subscription-based:** a subscription fee applies over a certain number of PDS integrated or transactions operated through the PDS by the new agribusiness or rural service provider

BARRIERS TO SCALE AND ADOPTION

- Reusability level of data from the agribusiness or service provider already engaged with the farmer
- Lack of supply side (i.e., agribusiness or rural service provider already engaged with the farmer) incentive to integrate with the PDS and share data
- Incentives and/or regulations ensuring the supply side integrates with the PDS rather than sharing data directly with the demand side (i.e., new agribusiness or rural service provider) is lacking
- Low trust in the data cooperatives managing the PDS for farmers [specifically in cases where the PDS is managed by a data cooperative]
- Low digital payment penetration
- Readiness of the new agribusiness or rural service provider to pay for the deployment and maintenance of the PDS infrastructure (especially if there is not a critical mass of farmers or data cooperatives using the system)

Data Ecosystem

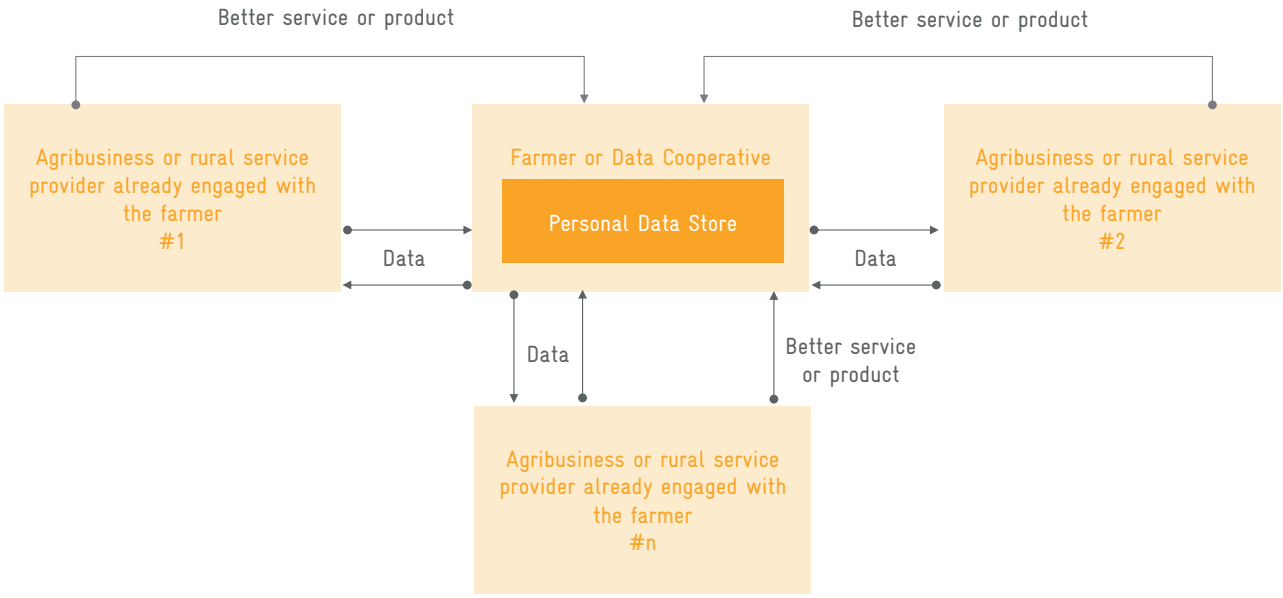
OPERATIONAL MODEL

In the context of the **Data Ecosystem**, farmers or data cooperatives centralise their data in PDS – or sets of PDS – to enable access to data from the community of agribusinesses and rural service providers already engaged with the farmers. The data is used by the community of agribusinesses and rural service providers to improve their value proposition by better knowing their customers, namely the farmers.

An example of the **Data Ecosystem** is a farmer using different digital solutions that are connected to a PDS, through which each solution provider can benefit from the data generated on the other service platforms.

The set of digital solutions includes an e-advisory solution, an IoT connected solar water pump, as well as an online marketplace to buy farm inputs. In this case, the e-advisory solution is made more dynamic and personalised thanks to the geolocation of the water pump as well as the types of inputs bought by the farmer on the marketplace.

Figure 15: Operational model of the Data Ecosystem



POTENTIAL INCENTIVES

- **Farmer:**
  - exercising more control over his/her data
  - obtaining insights from the data generated by/with the agribusiness or service provider
  - accessing better services and products
- Agribusiness or rural service provider:
  - maintaining its existing relationship with the farmers
  - service delivery and customer experience
  - eventually benefitting from the better services provided to the farmers (e.g., the input provider able to sell more to more aware and literate farmers)

POTENTIAL BUSINESS MODELS FOR THE PDS

- Subscription-based covered by the data cooperative: the data cooperative covers the cost of the subscription to access a deployed and maintained set of PDS
- Subscription-based covered by the agribusinesses and services providers: the different agribusinesses and service providers already engaged with the farmers cover the cost of the subscription to access a deployed and maintained PDS or set of PDS
- Hybrid subscription-based model: the cost of the deployment and maintenance of the PDS or PDS set is covered by both the data cooperative and the agribusinesses and service providers

BARRIERS TO SCALE AND ADOPTION

- Level of reusability and integrability of the data coming from the agribusinesses and service providers connected to the PDS
- Lack of supply side (i.e., agribusinesses or rural service providers already engaged with the farmer) incentive to integrate with the PDS and share data
- Lack of incentives and/or regulations to ensure the supply side integrates with the PDS rather than sharing data directly with the demand side
- Low trust in the data cooperatives managing the PDS for farmers [specifically in cases where the PDS is managed by a data cooperative]
- Low digital payment penetration
- Readiness of the data cooperatives and/or agribusinesses and service providers (especially if there is not a critical mass of farmers or data cooperatives using the system) to pay

Data Marketplace

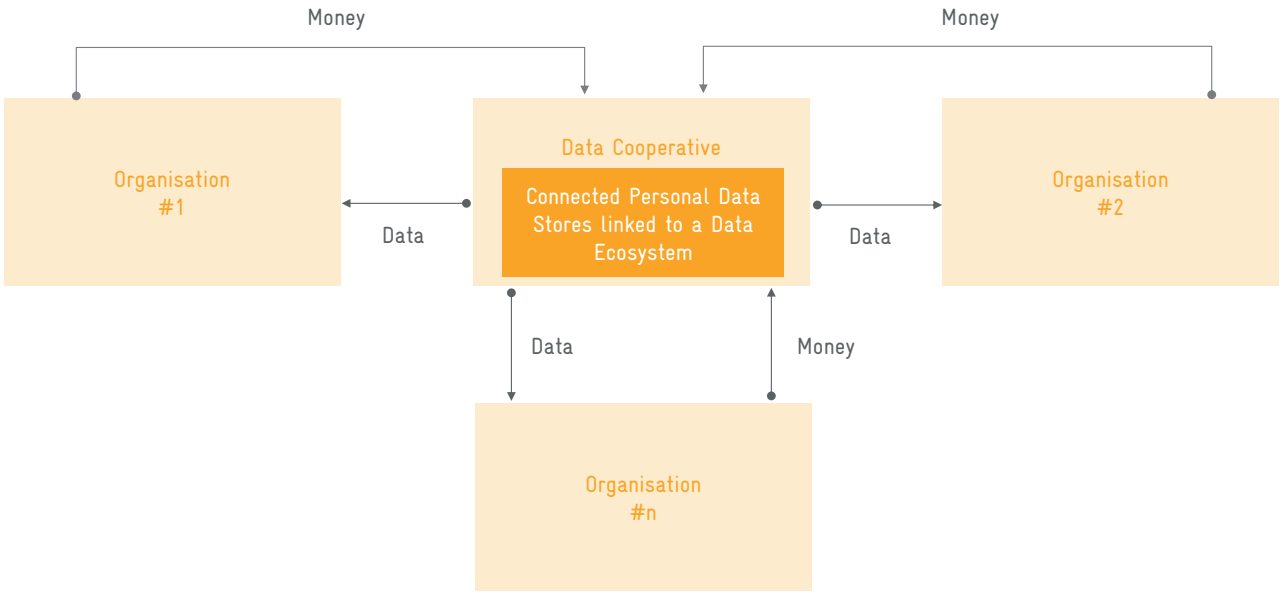
OPERATIONAL MODEL

In the context of the **Data Marketplace**, data cooperatives centralise the data from their members (i.e., the farmers) in a set of connected PDS in order to enable an open community of organisations access to the data. These organisations are ready to finance the aggregated data received from the data cooperatives. We believe that the **Data Marketplace** is only suitable to a data cooperative-based model since the marginal value of individual farmer data in LMICs is low.

Additionally, the **Data Marketplace** can only generate traction if the PDS are plugged into a **Data Ecosystem** which ensure availability of valuable data insights in the PDS.

An example of the **Data Marketplace** is when a group of coffee farmers delegated the monetisation of their data to a data cooperative and an off-taker pays this data cooperative in return for the aggregated market price data.

Figure 16: Operational model of the Data Marketplace



POTENTIAL INCENTIVES

- **Farmer:**
  - exercising more control over his/her data
  - obtaining insights from the data generated by/with the agribusiness or service provider
  - monetising their data
- Organisation financing the data insights: multiple incentives including but not limited to the ability to conduct impact assessment, informed policymaking, data-driven services and product design and delivery, identify new customers, etc.

POTENTIAL BUSINESS MODELS FOR THE PDS

- Similar business models to the Data Ecosystem with the addition that the pricing model can also be based on fees applied to each transaction between data cooperatives and financing organisations

BARRIERS TO SCALE AND ADOPTION

- Reusability level of data from the agribusiness or service provider already engaged with the farmer and connected to the underlying Data Ecosystem
- Low trust in the data cooperatives managing the PDS for farmers
- Lack of incentives and/or regulations to ensure the supply side integrates with the PDS rather than sharing data directly with the demand side (i.e., organisations paying for the data)
- Low trust from the demand side in the data itself
- Low digital payment penetration

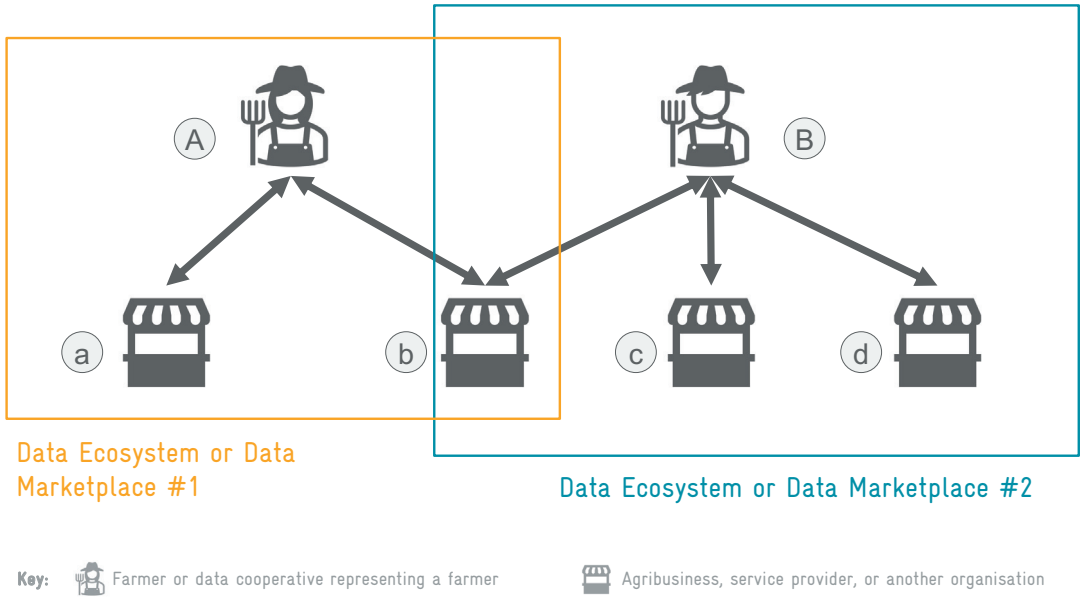
Cross cutting considerations regarding the different data sovereignty models

FINANCIAL SUSTAINABILITY

While the above visuals represent individual Data Sovereignty Siloes, 1-to-1 Data Sharing, Data Ecosystems, and Data Marketplaces, we believe that these models are especially sustainable if several siloes, sharing systems, ecosystems, and marketplaces are connected and integrated. The figure below illustrates two **Data Ecosystems,** or two **Data Marketplaces** connected by a common agribusiness, service provider, or another organisation.

In such a setup, the **Data Marketplaces** or **Data Ecosystems** are more sustainable as they benefit from each other. The cost of the PDS infrastructure can be allocated to both ecosystems and marketplaces. Additionally, the readiness to engage and pay for the PDS is higher for agribusinesses, service providers, or other organisations which are engaged in multiple ecosystems or marketplaces as they can access more data insights. This is, for example, the case of stakeholder (b).

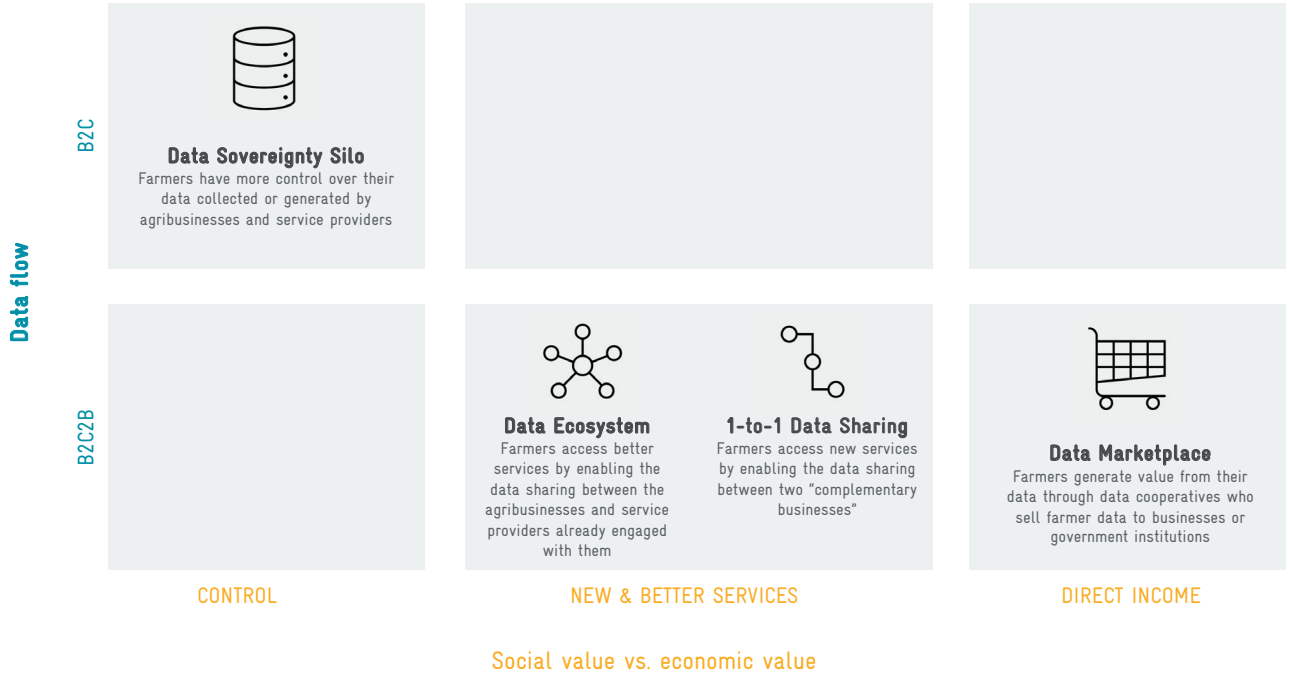
Figure 17: Connections between Data Ecosystems or Data Marketplaces



TYPES OF DATA FLOW AND GENERATED VALUE

The different models of data sovereignty can be mapped according to the type of data flow involved as well as the type of value generated from the data flow. When it comes to the data flow, we differentiate two types, namely business to consumer (B2C) and business to consumer to business (B2C2B). In this context, the consumer represents a farmer or group of farmers. Additionally, the business can also represent a non-profit or a public institution. Looking at the type of value generated from the data flow, the farmer can benefit from (i) more control over his/her data, (ii) better and new services, or (iii) direct income.

Figure 18: Data sovereignty models according to the type of data flows and value generated



ADDITIONAL MODELS

There are other data sovereignty models such as a public trust that present lower potential for agricultural value chains in LMICs. This entails a public entity, for example, a Ministry of Agriculture, collecting, accessing, and using data on farmers to inform public policy and address societal challenges. While such a model fosters public sector buy-in on the need for data sovereignty, it relies on a public agent as the data steward, who in most LMICs will often lack the capacity to effectively implement and sustain a data trust. Even in developed markets with more digitally literate users, the government is unlikely to be seen as a trusted data partner. In the EU, where the Data Governance Act (DGA) seeks to create a functioning data economy, stewardship roles are spread out across different data intermediaries, with governments playing a mostly regulatory role. While the aforementioned models provide an exhaustive overview of the way data sovereignty can be deployed in agricultural value chains in LMICs today, we believe that new models will arise as the digital transformation of these value chains progresses and the broader enabling environment evolves.

5.5. The role of blockchain and other decentralised technologies

Decentralised technologies will play a key role in making data more accessible and secure within and outside of agricultural value chains. Broadly, the decentralisation of technology involves breaking away from centralised to distributed forms of operation and exchange. Privacy concerns around infringement on personal information (e.g., through data breaches or unwanted surveillance), or even loss of data upon termination of an operator are key driving forces towards developing decentralised technologies. One highly anticipated technology is a decentralised internet or DWeb that will allow users to own and keep control of their data while maintaining free access to online content without relying on centralised operators. Companies like Solid, initially an MIT project led by Prof. Tim Berners-Lee, one of the inventors of the World Wide Web, are introducing new standards and specifications for web applications to allow true individual data ownership and improve privacy[33]. Other technology examples include the Internet of Things (IoT), the vast network of interconnected devices that exchange data over the internet, and Blockchain, a secure, encrypted technology that is most widely known for powering decentralised mediums of ex-

change or cryptocurrencies like Bitcoin and Ethereum, and other applications like self-enforcing or "smart" contracts.

Blockchain is a prime example of a decentralised technology within agricultural value chains, providing a decentralised public or private digital ledger of transactions that can increase transparency, security, immutability, and enable more control over data. Blockchain helps to build trust along chains of individuals and organisations, especially where financial transactions are involved, which can address the low institutional trust that farmers have in current systems. For example, data relating to transactions around the purchase or usage of land and other agricultural resources can be securely recorded by generating immutable transactions that are visible and independently verifiable by each relevant stakeholder, including the farmer, by showing the flows of finance (e.g., payments, across the value chain)[34]. Online agriculture marketplaces such as the e-commerce platform Agrikore by Cellulant are also using blockchain-based smart contracts to securely record transactions across the vast activity of trade between farmers, input providers, aggregators, FMCG businesses, financial service providers, insurance companies, etc[35] . Blockchain can also be used to incorporate traceability functionalities to verify the source of agricultural produce and create accountability for equitable commercial practices. For example, in some coffee value chains, blockchain has been leveraged to connect European consumers based in Amsterdam to the producers in Ethiopia by tracing who produced the coffee and how much they and their intermediaries earned from sales[36]. When integrated with certification programmes, this also offers the consumer other quality checks to ensure that there is no or minimal malpractice in the production of the commodity, for example, the use of child labour, and deforestation or other forms of environmental degradation.

Key innovators within the sector project increased use of new and decentralised technologies, but also recognise the existing systemic bottlenecks to adoption. 60% of digitisation for agriculture (D4Ag) enterprises across Africa surveyed by CTA expect that they will integrate new technologies like blockchain, IoT, and machine learning over the next three years[37]. Innovators, however, also acknowledge the preconditions that must be met for blockchain to work meaningfully within smallholder farming communities in LMICs, such as the digitisation and standardisation of paper-based data to create electronic records, and the creation of digital identities as a prerequisite for authentication of farmers (e.g., as part of traceability applications or to create verifiable financial histories), and more broadly to allow them to use any application that would offer them better control of their data. Other issues of governance, such as pervasive corruption and fraud in some countries or specific institutions will also need to be addressed to maintain the integrity and immutability of blockchain ledger records[38].

5.6. Trade-offs when building data sovereignty

A key challenge in fostering data sovereignty is to strike a balance between strengthening farmers' control over their data and improving data transactions between all stakeholder groups while allowing for continued use of data for commercial and non-commercial purposes, and for the growth and innovation of the sector. A wide range of stakeholders rely on agricultural data to inform policymaking within the sector, for the innovation of new products and services, and to improve coordination across agricultural value chains. Therefore, efforts should consider certain key parameters that need to be adjusted or examined when building data sovereignty:

- **Disruption – What are current structures and standards of data management within agriculture value chains and which ones should be transformed vs. maintained?** To reduce the barriers and challenges to foster data sovereignty, it is critical to build on what already exists and avoid (as much as possible) transforming the processes, rules, standards, and solutions which can be maintained in light of the most critical data sovereignty objectives. For example, codification of consent and ownership rules in legal contracts between farmers and companies may need to be simply strengthened or clarified, while data sharing mechanisms may need to be transformed to place focus at the group level (e.g., through producer cooperatives rather than on individual farmers to support scale).
- **Incentives – What incentives are available to farmers and businesses in exchange for their data and participation and are they meaningful and sustainable?** Incentives are an important consideration to ensure uptake and adoption of a new solution aimed at building data sovereignty. The level of control that is targeted by the intervention and its resulting cons-

traints on the engaged stakeholders needs to be aligned with the incentives offered by the solution.

- **Trust – Is the level of trust of the engaged stakeholders adapted to objectives of the data sovereignty intervention?** Similar to the incentives, the stakeholders engaged in a data sovereignty initiative need to trust the governance in place. The scope of the initiative needs to be aligned with that level of trust which usually has to be built over time.
- **User friendliness – What is the right level of complexity to enable a greater control of farmers over their data without discouraging them from engaging with the data sovereignty solution, service, or programme?** Learning and onboarding efforts might become a barrier for the different parties engaged in the data sovereignty initiative. For example, if user-facing technologies are too complex, farmers require extensive and rigorous upskilling, which distracts from their primary value-addition and income-generating activities.
- **Inclusivity – How can stakeholders ensure that new innovations towards data sovereignty are not excluding communities of smallholder farmers?** For example, enforcing a fair traceability technology in a value chain to meet the demands of sustainability-driven consumers, especially as a prerequisite for international trade, may exclude smallholders who lack the capacity and resources to adopt the new solution.

Considering this, data sovereignty needs to be optimised not just for farmers but for all key market functions across agricultural value chains. Recognising variations in maturity and readiness of the value chain stakeholders and broader enabling environment is important, as is careful consideration of the implications of rapidly innovating the current standards and methods of data management.

VI. CASE STUDIES OF DATA SOVEREIGNTY INTERVENTIONS

Data sovereignty for farmers, increasingly seen as an important topic globally, is especially timely for smallholder farmers across low and middle-income countries, who continue to be ushered into the digital era while receiving the lowest value in the food systems. Increasingly, digital agriculture transformation efforts are beginning to include a data protection and privacy lens to the interventions, looking at how farmers are exercising ownership and control over their data and how they are benefiting from the resulting value. The topic of data sovereignty for farmers has also attracted the attention of stakeholders from across private, public, research, and development lines, with most current interventions featuring a diverse mix of partners working in collaboration.

Case studies across the three types of interventions (see section 5.2) are profiled as follows:

- **Indirect interventions –** Some government stakeholders are developing frameworks for better data governance at the national level, paying closer attention to the role that smallholder farmers play in the control of their data. One example is the **Indian Digital Ecosystem for Agriculture (IDEA) framework** or **AgriStack, a top-down framework developed by the Indian Ministry of Agriculture** and Farmer Welfare in consultation with industry experts. AgriStack aims to create a comprehensive digital environment to allow a wide range of agro-stakeholders access to agricultural datasets e.g., weather forecasts, land reports, commodity prices, soil health status, irrigation data, banking and insurance information, farmer assets, and so on[39]. Follow-on implementation of AgriStack will be owned at the regional level; for example, the state of Odisha has created the Krushak Farmer Database, a state database of 7.6 million farmers, that will streamline delivery of digital services to local farmers. The Ministry sees consent over farmer data as a critical layer to AgriStack in protecting farmers' rights to privacy but the Ministry has yet to integrate it into the design of the framework[40].

- **Intermediary interventions –** Other stakeholders are directly undertaking projects to build a data infrastructure and implement data and digital solutions that foster data sovereignty for farmers. One example is the **Digital Agricultural Advisory Services (DAAS) project in Ethiopia** implemented by **Digital Green** and a consortium of partners. Digital Green has developed a software called FarmStack, an open-source protocol that allows secure and trusted data transfers between agroecosystem actors, including consent sharing by farmers[41].

- **Direct interventions –** Where there is already a level of digitisation of agricultural value chains, market actors can move into direct implementation without having to build a foundational layer of data sovereignty. **The International Dairy Data Exchange Network (iDDEN)**, the largest international dairy data partnership, is streamlining data exchange services and integration between dairy equipment and national dairy information systems. The network has created a single data interface for manufacturers, milk collecting organisations, and farm service providers to connect to each other, while ensuring that dairy farmers retain control over their data[42].

CASE STUDY #1 – INDIRECT INTERVENTION: Indian Ministry of Agriculture promoting policy frameworks that enable better data governance and sovereignty

Overview

The Ministry of Agriculture and Animal Welfare in India launched the India Digital Ecosystem for Agriculture (IDEA) framework in June 2021, known also as AgriStack, with the aim of digitally transforming the agricultural landscape. It includes a provision of a data governance structure for all agroecosystem stakeholders.

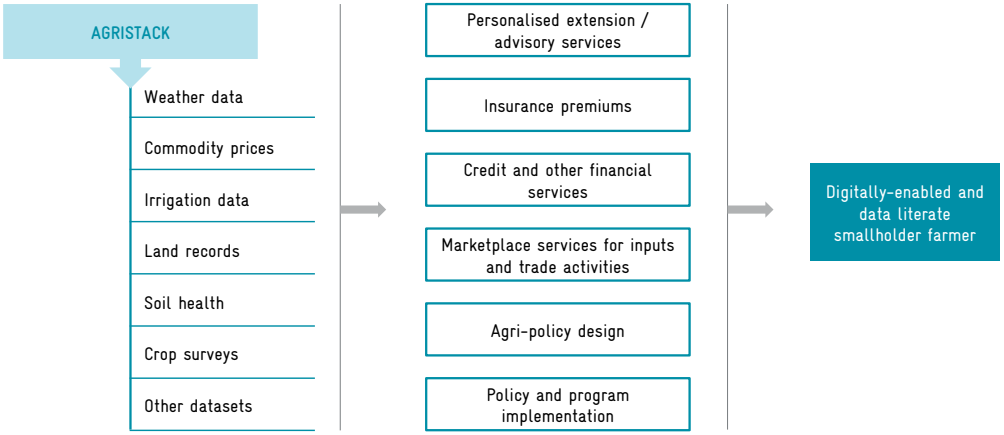
In its current format, AgriStack lacks a clear agenda for the integration of data privacy and consent layers. However, such top-down interventions driven by the public sector are critical building blocks to enabling data sovereignty.

If effectively implemented, AgriStack will address major barriers to data governance such as low levels of digitisation, and data access, literacy, and awareness. Smallholder farmers will be able to get authenticated for and more easily onboarded onto digital services, paving the way for data sovereignty solutions.

Operating model

AgriStack is structured as a central data registry that pools datasets across several types of digital agricultural information to enable cost-effective delivery of agricultural advisory services via digital channels. Datasets of weather and irrigation data, crop prices and surveys, land records, and so on, can be accessed by various digital service providers to inform service design and deliver personalised options to farmers across the country.

Figure 19: Illustration of AgriStack framework



Key partners

The Ministry of Agriculture is working with different partners to leverage different capabilities for implementation and continuous improvement of AgriStack. Key public partners include the Ministry of Electronics and IT and the National Payments Corporation of India (NPCI). Private partners include corporations like Microsoft, which is supporting a pilot project in 100 villages to develop stronger farmer interface with digital solutions, through a local partner, CropData.

Technology component

The most important core building block of IDEA is the Unified Farmer User Interface (UFSI) which enables the data providers and data consumers to exchange data in an efficient, transparent, and streamlined manner through a large set of APIs. The different building blocks of IDEA's infrastructure are available in the consultation paper published by the Government of India in June 2021, available at this link.

Path to sustainability

AgriStack is designed to be an open source and open standards framework to encourage innovation and ownership of new solutions within the ecosystem. While the core building blocks will be designed, developed, and maintained by the Government of India, the common building blocks (reusable functionalities) and reference building blocks (generic, customisable functionalities) will be published as open-source components for download by individual states, private sector companies, and other ecosystem entities.

CASE STUDY #2 – INTERMEDIARY INTERVENTION: Digital Green enabling farmer consent sharing and trusted data transfers between agroecosystem actors in Ethiopia

Overview

Digital Green, an Agri-tech start-up, is leading a consortium of partners in Ethiopia under the Digital Agricultural Advisory Services (DAAS) project, a 5-year initiative running from 2019-2024 that aims to enable trusted data transfers for cost-effective delivery of agricultural advisory services via digital channels.

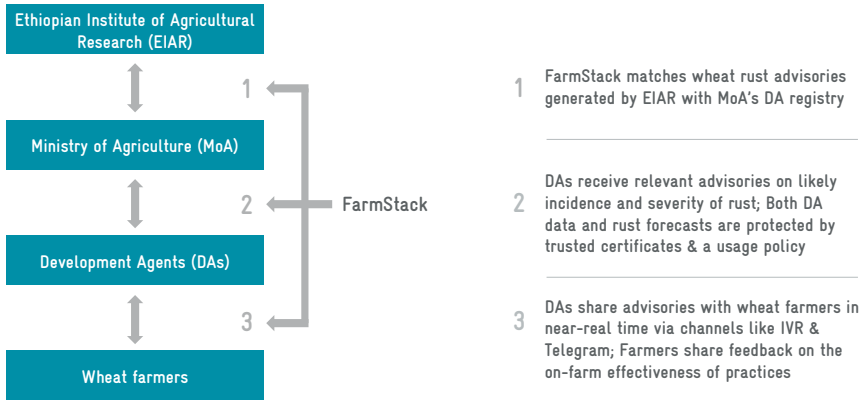
With strengthened extension systems in high-impact value chains or use cases, farmers can receive relevant and timely advisories that allow them to increase yields and incomes and become more resilient to climate change.

Under DAAS, Digital Green is creating registries of static farmer data, i.e., data points that are unlikely to change, like gender and plot size, with the goal of profiling over 2.5 million farmers.

Operating model

FarmStack allows farmers to consent to securely and privately sharing their personal data with DAAS participating organisations, who in turn can securely share data on their own terms, access farmer feedback, and leverage data assets within the platform to refine the design and delivery of solutions to farmers.

Figure 20: Illustration of wheat rust use case powered by FarmStack



Key partners

Consortium partners
- Government of Ethiopia's Ministry of Agriculture (MoA)
- Ethiopian Agricultural Transformation Agency (ATA)
- Precision Agriculture for Development

Content, channel, and technical partners
- International Maize and Wheat Improvement Centre
- International Livestock Research Institute
- Land O'Lakes
- CABIbloc
- CARE

Project auditor (monitoring & evaluation)
American Institute of Research

Technology component

The project is built around a platform called FarmStack, an open-source software that ensures trusted B2B to B2C data exchanges and digitally codifies usage policies and standards. FarmStack is designed as a decentralised system which can be connected to a wide range of relational database management systems. The complete documentation of the solution is available on their wiki at this link.

Path to sustainability

Digital Green will transfer ownership of the implementation of FarmStack to the public partners on the project. DAAS will build the capacity of MoA's extension and ICT directorates to support design and implementation of use cases and maintain FarmStack in the future.

CASE STUDY #3 – DIRECT INTERVENTION: iDDEN enables farmer control and trusted international data exchanges between dairy value chain stakeholders

Overview

The International Dairy Data Exchange Network (iDDEN) is the largest international dairy data partnership designed to streamline data exchange for data-driven decisions and innovative industry services.

iDDEN brings together milk recording organisations and national databases across 13 countries, representing an estimated 200,000 dairy herds. The network officially launched in October 2020 and is headquartered in Germany.

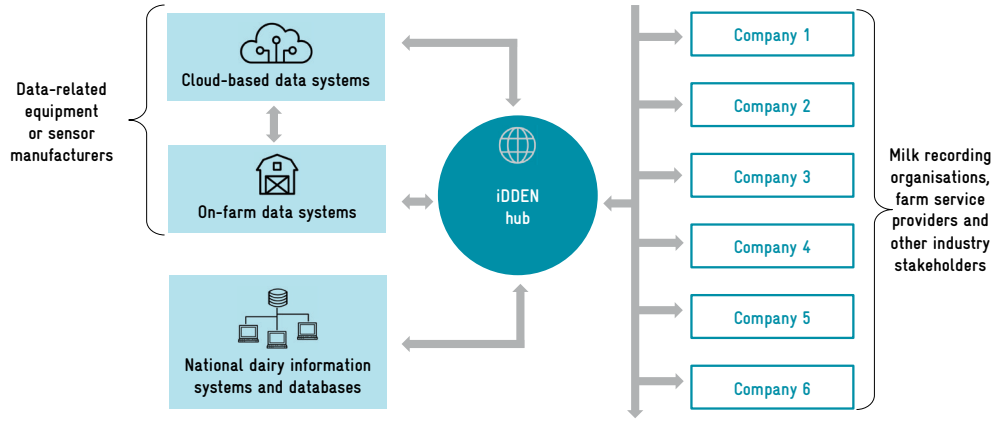
The network is primarily active in developed markets, where there is already a strong level of digitisation of agricultural value chains, and an existing foundational layer of data sovereignty.

Operating model

iDDEN delivers data-exchange services that seamlessly integrate on-farm dairy equipment with national dairy information systems and databases. The iDDEN framework offers distinct advantages to its users:

- Dairy farmers retain control as they must authorise access to and the use of their data
- Manufacturers obtain a single universal interface with dairy cooperatives around the world
- Milk recording organisations and other farm service providers also have a single universal data interface

Figure 21: Illustration of data exchange service delivery via the iDDEN hub



Key partners

iDDEN is composed of 7 founding organisations representing 13 countries to date, with opportunities to expand.
Organisations include:

- CRV (Netherlands)
- DataGene (Australia)
- Lactanet (Canada)
- National Dairy Herd Information Association (USA)
- NCDX (Denmark, Iceland, Finland, Norway, Sweden)
- RDV (Austria & Germany)
- Vit (Germany)

Technology component

iDDEN purchased an existing platform called the Nordic Cattle Data eXchange (NCDX) digital platform and is further investing in connecting the data exchange hub to on-farm and cloud-based systems of major manufacturers' dairy-related equipment and software as well as sensors (e.g., heat detection, milk composition, health and disease diagnostics, etc). More information on the iDDEN infrastructure is available at this link.

Path to sustainability

iDDEN continues to look for opportunities to scale into new markets and expand its network. iDDEN also integrates data sharing standards and guidelines from the International Committee for Animal Recording Animal Data Exchange (ICAR-ADE), where guidelines exist, to ensure compliance among members.

VII. RECOMMENDATIONS TO SUPPORT ACTORS

Existing initiatives as outlined in the case studies above are laying the critical building blocks for data sovereignty by testing key protocols around consent and other forms of data control by smallholder farmers. However, the LMIC market is still at a very early stage of solutions development and critical gaps persist.

Different stakeholder groups can play strategic roles based on interest and expertise to bridge existing market gaps and accelerate the private and public sectors towards increased data sovereignty in agricultural value chains. This translates to the following approach:

- Thought leadership to assess the current situation and provide strategic guidance and vision
- Ecosystem management to connect relevant partners and create supportive dynamics
- Technical assistance to identify a critical path and critical building blocks and modules to secure
- Funding support to secure critical mass and potential for piloting and scale-up
- Value chain integration to translate mobilisation efforts into implementation on the ground

The framework below maps out the key recommendations proposed across a range of stakeholders based on a relevance scale. In the context of this framework and broader study, we think of relevance as follows:

1. **High relevance:** Stakeholder is the primary initiator, driver, or decision maker in the activities associated with the recommendation.
2. **Some relevance:** Stakeholder is a participant or eventual owner of the recommendation, i.e., assumes responsibility over the long-term for sustainability purposes.
3. **Low relevance:** Stakeholder is a beneficiary of outcomes resulting from the activities around a recommendation.

Our analysis of which recommendations each stakeholder group is best positioned to drive is also a function of the geographical focus of this study – low- and middle-income countries (LMICs) – and the on-the-ground realities in these markets today. Readers should keep in mind that in a different or narrower geographical context, the framework could emerge differently.

To avoid the top-down data sharing or product lock-in scenarios described earlier, farmers must be placed at the centre of solutions as co-creators or as focal points for design and usage (farmer-centred design). This also applies to recommendations that are less directed towards producers. Ultimately, data sovereignty can only be meaningful and useful where there is farmer buy-in.

Figure 22: Relevance of key recommendations across stakeholder groups

KEY RECOMMENDATIONS			Agribusinesses (Producers including farmer cooperatives; Traders; Whole-salers; Transporters; Retailers; Input & Extension service providers)	Agriculture service providers (Digital service providers e.g., AgTechs; Advisory service providers e.g., SME consultancies)	Data governance experts (Private companies; Research & Academia teams; Civil society organisations)	Development organisations (Country development agencies; UN bureaus; Aid organisation)	Financiers (Donors; Commercial capital e.g., Local / Development banks, Private Equity, Venture Capital; Family offices)	Policy leaders (Ministries of Agriculture; National agriculture organisations; Regional agriculture bodies)
Global	**Thought leadership**	Ecosystem readiness assessment	1	2	3	3	1	2
		Articulating business & impact use cases	2	3	3	3	1	2
	Ecosystem management	Mapping champions & flagship use cases	1	2	3	3	2	1
		Matchmaking & partnerships facilitation	1	2	2	3	2	1
		Facilitating knowledge transfers	1	2	3	3	2	1
	Technical Assistance	Capacity building	1	1	3	3	2	2
		Shaping the regulatory environment	1	2	2	3	2	3
	Financing	Grant provisions	1	1	2	3	3	2
		Catalysing financing for commercial models	1	1	1	2	3	1
		Advising public budgets for D4Ag	1	2	3	3	2	3
Local	**Value chain integration**	Shaping market demand	3	2	1	2	2	2
		Digitising key agricultural processes	3	3	1	1	1	2
		Engaging local policy & business leaders	3	3	3	2	1	3

7.1. Thought leadership

Stakeholders like data governance experts and development organizations, with the support of agriculture service providers and policy leaders, drive the thinking around priority market entry points for data sovereignty interventions. They do so based on ecosystem readiness, mobilising resources around high-potential business and impact use cases.

Ecosystem readiness assessment

In prioritising resources for intervention, developing a deeper understanding of the market landscape within low and middle-income countries is key. Assess the relative readiness of different ecosystems for data sovereignty interventions. Key feasibility indicators can be built around the individual, organisational, and ecosystem enablers outlined in the data sovereignty framework and how they manifest in the market.

Assessing readiness at the individual and organisational level

Assess the readiness of the farmer associations as the primary medium of interventions; initially focus on markets where the ideal combination of association profiles exists. In addition to gauging the levels of key enablers like access, literacy, and awareness, consider the composition of farmer associations and how they may inform readiness for intervention.

Associations with a larger scale of commercial activity are more likely to be early adopters of data sovereignty-related interventions. Subsistence farmers who produce on a micro-scale, typically to meet their immediate individual and family needs, have different primary concerns than smallholder farmers who produce on a commercial scale with more commercial crops (e.g., coffee, cocoa, cashew nuts). While subsistence farmers are primarily concerned with access to finance and inputs, commercial farmers seek out better market linkages, prices, digital advisory services, and pathways to scale. Many farmers associations work with a mix of farmer types since commercial farmers often absorb subsistence farmers as farm labour.

The likelihood of adoption is also higher among more mature cooperatives; younger farmer groups are more focused on activities around the key crop in production and on driving direct and tangible benefits for members, such as bringing in advisory services, creating market linkages, getting better prices, securing loans, etc. Mature cooperatives on the other hand are typically more willing to explore technological solutions that can help manage a larger base, greater resources, and achieve more ambitious productivity goals e.g., reaching export markets.

One outcome from such an assessment should also include the critical path that could accelerate the digital maturity of organisations and individuals. The aim would be to design an approach and identify key building blocks. In cases where data sovereignty is a longer-term goal, the outcome could be to incrementally strengthen the enabling environment.

Assessing readiness at the ecosystem level

Regulatory framework – Seek out evidence of public sector buy-in such as government-backed consolidated data platforms, or policies or national strategies that show a high appetite for smart and fair data use, or, more broadly, digital innovations. Supportive enforcement measures through a relevant data authority are also key to meaningful public backing. As stated earlier, regulation also acts as an incentive, for example, in ensuring compliance among data collectors. It is important to underline that any regulatory framework will not be sufficient per se. GDPR, for example, has required multiple adjustments (e.g., Data Governance Act, Digital Services Act, Digital Market Act) to fill the gap between a legal basis and its operational impact.

Business environment – The presence and traction of private sector-enabled digital agriculture solutions also act as indicators for the potential success of a data sovereignty intervention. In addition to public sector support, a fast-growing digital agriculture landscape indicates investment and advisory support of the ecosystem and strong farmer onboarding. The presence of data cooperatives or other ecosystem support actors should also be considered. Research organisations such as CGIAR can play a role in equipping LMICs to manage and use their agricultural data more effectively, for example, by adding the initial layers of digitisation to public data.

Digital enablers – Other readiness indicators can include consistent efforts towards digitisation beyond connectivity, e.g., the creation of digital identities for farmers and minimal government interference to free market plays as in the mobile internet market. Fair competition among digital service providers also drives enablers such as data portability so that farmers have access to the most competitive products and services.

Suggestions for implementation

Conduct an ecosystem readiness study that identifies, defines, and weights the critical success factors for intervention (building on the data sovereignty framework) while ranking key geographies based on potential for success for data sovereignty interventions.

While a more refined analysis on market readiness is needed, there are a few low- and middle-income countries that show initial signs of promise for early intervention. In South Asia, India is a good example. There is public sector buy-in through the Indian Digital Ecosystem for Agriculture (IDEA) framework or AgriStack that is driving efforts such as digital ID for farmers, as well as a thriving agri-tech business ecosystem of start-ups and broader coalitions like ThinkAg, a multi-stakeholder platform connecting cooperatives, providers, and the public sector. In Sub-Saharan Africa, the governments of Ethiopia and Kenya have both supported the creation of public data registries such as the Kenya Integrated Agriculture Management Information System (KIAMIS) led by the FAO and the ongoing efforts in Ethiopia supported by Digital Green. In Latin America, the World Bank is currently supporting the government of Mexico in designing and building a data platform to create more structured access to finance-related data, including agricultural finance[43].

Articulating relevant business & impact use cases

With data sovereignty still an emerging concept, many stakeholders do not yet understand its importance and how it can be practically applied in real business and programmatic settings. Thought leaders can act as consensus builders around the potential of data sovereignty. On the private sector side, this means developing feasible business cases for profitability or other ways in which private companies can benefit from adding consent and other control layers onto the data generated by their solutions. On the public sector side, this will largely be around building the impact case of data sovereignty for the greater public good. Stakeholders can also bridge the different incentives on either side by facilitating conversations that demonstrate how shared goals can be achieved through public-private partnerships (PPPs). Similarly, stakeholders can unite the private and public sectors on how various impact lenses can be applied to data sovereignty, for example, the gender, climate, sustainability lenses, and other targets in line with the SDGs.

Suggestions for implementation

Develop business and impact case frameworks focused on specific ecosystem needs in target countries. These frameworks can consist of a set of critical success factors considered instrumental to assessing when developing a new data sovereignty intervention or measuring the potential of an existing one. Examples of success factors could include the levels of engagement of vulnerable groups such as women, youth, and refugees, the presence of existing initiatives or partnerships, or the potential for the use case to absorb capital for scale. The objective would be to prioritise the use cases that offer a balance between ease of entry, scalability, and impact potential.

Additionally, develop or refine impact measurement approaches to assess the effectiveness of interventions and alignment with gender and climate objectives.

7.2. Ecosystem management

The same groups of stakeholders, with added support from financiers, can support mapping efforts of champions and flagship use cases and acts as a third-party facilitator for ecosystem matchmaking and partnerships and learning engagements.

Mapping champions and flagship use cases

Based on the identified entry markets and use cases, conduct a very targeted mapping of key actors and initiatives across the public and private sectors. The goal will be to clearly identify (i) flagship data sovereignty use cases and (ii) connections that are strategic and beneficial in various on-the-ground interventions and who can serve as data sovereignty champions. For example, individual data control solutions or programmes which work at scale, government institutions who successfully deployed a control layer in an agriculture data ecosystem, or private companies integrating data control protocols into their solutions.

Suggestions for implementation

The mapping exercise can be bundled with the ecosystem readiness assessment and/or use case study. It can consist primarily of desk research and be complemented with stakeholder interviews, using a representative sample of private, public, civil society, and development actors. Additionally, this mapping can build on existing international initiatives already gathering organisations active at the intersection of digital and agriculture such as the Global Coalition for Digital Food Systems.

Matchmaking and partnerships facilitation

Ecosystem connectors can play a third-party facilitator role to match or connect private data innovators to each other and to government and development champions. Our interview process revealed a lack of dialogue in the market between stakeholders who share a data sovereignty interest and the absence of a coordinated effort to drive such partnerships forward. Stakeholders can bridge this gap by creating a governance structure to manage in-country stakeholder engagement and coordination.

Suggestions for implementation

Establish a data sovereignty technical working group (TWG) or coalition to bring together key actors and create centralised and localised knowledge management about data sovereignty. Groups can be formed at the country, regional, or global levels.

Shape the agenda of the TWG. Key responsibilities should include facilitating local co-creation efforts, serving an advisory function to ecosystem connectors, government bodies, farmer cooperatives, and the broader market, and informing the market through dissemination of findings via convenings, publications, or other media.

Design the governance structure for the TWG, for example, a Secretariat. One market example is the Smart Communities Coalition, a group founded by USAID and Mastercard consisting of 60+ private and development organisations all mobilised around the challenge of service delivery to displaced people. It is governed by a six-person Secretariat comprised of sub-contracted individuals in strategic countries[44].

Facilitating knowledge transfers

Actors like GIZ are already playing a catalytic role in developing analyses around data sovereignty and governance through studies such as this one and in facilitating stakeholder discussions. As the concept and landscape of data sovereignty gains clarity and consensus, and as new solutions gain traction, it will be important for more stakeholders to lead and support such efforts. While each in-country implementation will look different, there will be cross-market learnings on best practices such as approaches to partnerships, product design, training, capacity building of farmers, and so on. Intentional knowledge management and transfers are key to ensuring that the next generation of digital agricultural interventions are designed with a data sovereignty lens.

Suggestions for implementation

Organise and facilitate learning events, workshops, and other appropriate virtual or physical stakeholder convenings. South-South knowledge transfer will be especially relevant to the topic at hand.

Coordinate with organisations like the OECD to facilitate North-South or South-North knowledge transfer. As an example, pilot interventions in LMICs can be informed by existing findings from more developed regions, where aspects of data sovereignty already have more prominence. The issues and concerns that farmers in higher income countries have regarding their data offer a valuable lesson to the controls that should be set in place in low and middle-income countries.

7.3. Technical assistance

All stakeholders, with the exception of agribusinesses, can serve as technical support partners (with varying levels and areas of expertise) in developing a knowledge and skills base for the business and policy advancement of data sovereignty.

Capacity building

Data sovereignty is a relatively new idea across farmer, private, public, and development groups. There is therefore a large need to build up the knowledge and, where relevant, data and digital capacity, of key stakeholders. Each stakeholder should consider how they are uniquely placed to orient local knowledge and skills around high-potential markets and use cases to build an early set of success stories that can generate excitement and momentum through experiential learning.

Suggestions for implementation

Capacity building exercises could be facilitated by the aforementioned technical working group. Stakeholders can also support local business advisory and incubation actors to absorb relevant business models into their training and acceleration programmes.

Shaping the regulatory environment

Regulations such as GDPR continue to serve as an international standard for data governance, with many LMIC governments borrowing heavily from the framework. However, this results in policies that are not contextualised to the economic realities and the relatively limited digital capacity of these countries. Stakeholders should therefore seek to play a larger role in shaping the regulatory environments of target markets by building relationships with government departments that play a policymaking role.

Suggestions for implementation

Support technical audits of the digital infrastructure in key government functions as it relates to data sovereignty. When paired with a needs assessment this can help to identify critical gaps for intervention and inform policy at the national and even regional level.

Support policymakers in integrating data sovereignty aspects into new or existing Agtech strategies. The recently launched Continental Agtech Blueprint for Africa, which aims to support African nations to accelerate agricultural productivity — among other sector outcomes such as infrastructure and connectivity — using Information and Communications Technology (ICT) is one example of this[45].

7.4. Financing

Stakeholders with financing capacity can catalyse grant funding for the pilot implementation of promising business and operational models, mobilise commercial financing for scaling, and advise governments on public spending.

Grant provisions

Act as a catalyst for data sovereignty solutions by offering grant provisions for proofs of concept to eligible not-for-profit organisations. Alternatively, grant financing can be extended to private sector companies through public-private match funding modalities. Grants or other patient capital will be an important financial incentive during the piloting or beta phases of product development as companies rely on early adopters for revenue and need a safe financial net in which to prove unit economics (viability at scale).

As the topic of data sovereignty or governance gains more traction and excitement within the venture capital community, agri-tech companies may be led into raising funding that does not meet their growth needs. There is evidence of new technologies scaling and achieving rapid growth with early equity investors but after raising more capital are forced to downsize and overhaul their cost structure. Financiers can play a leading role in curating a class of emerging solutions and helping them to graduate from grants or concessional financing to more commercial forms of capital.

Suggestions for implementation

Dedicate specific funding opportunities to proofs of concept of relevant innovations in high-priority countries and use cases of data sovereignty. Proofs of concept can take different forms, from initial pilots to new market entries to early scale-ups. Funding can be paired with technical assistance and partnership facilitation, as outlined earlier.

Catalysing financing for commercial models

Following early market adoption of high-potential solutions local financial advisory firms can play a key role in identifying and supporting scalable proof of concepts to become investment ready, as well as supporting capital raising for relevant business models to scale with a clear data sovereignty angle. Venture finance will also play an important role in sustaining the penetration of data sovereignty technologies across the Agtech ecosystem, especially given the shortage of funding beyond pilot projects in the international development space.

Suggestions for implementation

Engage local advisory firms who are equipped to extend financial technical assistance (e.g., capital raising support), to Agtech companies scaling relevant business models.

Advising public budgets for d4ag

As shown in the analysis on the current state of the regulatory environment in LMICs, while a good number of countries have adapted European data regulations and acts to draft local data laws, there is still a prevailing lack of understanding of the value of data and data sovereignty. Development partners and data governance experts are well-positioned to take on a support role to help public stakeholders appropriately allocate public funding. For example, many LMICs still lack or have inactive data enforcement authorities to implement the data regulations. Such actors can help to establish the mandate of these offices to inform budget spending on data and maintenance of data, which requires varying levels of complexity based on a country's government structure. Advocate further for data sovereignty solutions to be included in public innovation funds to encourage governments to have a stake in their success.

7.5. Value chain integration

Agricultural value chain actors at the most granular level are best positioned to translate both the thinking behind and the ecosystem strengthening data sovereignty into practical solutions for implementation within Ag ventures across different stages of growth.

Shaping market demand for data sovereignty

As the primary producers of value within the agricultural value chain, farmers and farmer cooperatives have untapped influence for raising awareness around data privacy needs. They can gradually shift the industry towards more favourable data sovereignty practices. Farmers cannot, however, achieve this shift in isolation – an ecosystemic approach calling on other users of D4Ag solutions is required. These users, such as aggregators and input providers that use online marketplaces or transporters that use delivery apps can be considered in order to gain an appreciation of the value of farmer agency over data, recognize policies around data protections, and design responsive products and services to that end.

Suggestions for implementation

Producer demand is ultimately shaped by awareness and understanding of the importance of data sovereignty. As part of technical assistance and capacity building efforts, value chain actors across market functions should be given the opportunity to engage directly on the topic and share different perspectives e.g., through workshops, conferences, and other forums. Additionally, on the supply side sector, support partners such as financiers, industry advisors, and development partners can encourage digital Ag service providers to design products taking data sovereignty of farmers into consideration.

Digitizing and building capacity around key agricultural operations

While digital agricultural solutions evolve to meet new market expectations around data sovereignty, farmers and farmer cooperatives must themselves be adequately equipped to take up such solutions.

Suggestions for implementation

Cooperative leaders can play a key role in bridging the digital divide by promoting uptake and usage of handheld mobile devices, penetration of internet connectivity, and other essential digital services while working with service and credit providers. Cooperatives offer much-needed entry channels into the market base that digital and financial Ag providers need, thereby giving the cooperative bargaining power and strengthening the supply and demand dynamic around data sovereignty. The same can be said for other traditional value chain actors like aggregators and wholesalers, who also often organise within similar group associations.

Engaging local business and policy leaders

While development actors may have more prominent or frequent opportunities to engage policy leaders on the issue of data sovereignty, policymakers will ultimately be swayed by the voices of farmers and other value chain stakeholders and require farmer representation as part of any efforts to create meaningful regulatory change.

Suggestions for implementation

Traditional value chain actors, from producers and input providers to retailers, should be equally vocal on the issue of data sovereignty, and, more broadly, data protections. Opportunities to engage policy leaders directly vary widely from local government (local council, parish, district leaders) to the state (Ag secretaries, ministers, national, and regional bodies). Farmers can start engaging in this discourse wherever they are already plugged in. Indirect engagement is also often available via extension officers and field agents. Larger, commercial value chain players who wield greater influence should back the message and set an example in the industry.

VIII. CONCLUSION

This study highlights data sovereignty in agricultural value chains as an important and timely topic that warrants the attention of stakeholders across the agricultural ecosystem. The business and impact cases demonstrate the yet-unlocked direct and indirect livelihood opportunities presented by increased farmer control over their data. Additionally, the role that emerging technologies such as blockchain can play in data sovereignty applications presents new and exciting opportunities for the further technological advancement of agricultural value chains.

Data sovereignty for smallholder farmers in LMICs is still at a very nascent stage; many stakeholders are only just starting to understand it and there is yet to be a consensus around a defining framework. Furthermore, while many actors acknowledge privacy and consent gaps in the current modes of farmer data collection and sharing, some actors question the technical feasibility of establishing full farmer control given the underdeveloped data access, literacy, and awareness among smallholders in LMICs. Others are sceptical about the business opportunities that can result in direct financial impact to farmers — specifically, the willingness of digital service providers to pay farmers for their data. The questions and concerns raised further show the need to establish a level of agreement around the types of data governance models that would operate best given the existing constraints.

Industry stakeholders across agricultural value chains and market functions can play strategic roles as thought, technical, funding, and implementation partners in developing responsive data sovereignty interventions for smallholder farmers. For thought partners, there is still much work to be done around structuring the thinking on the topic, from prioritising geographies for initial intervention based on ecosystem readiness to mapping use cases and strategizing with government partners. For technical, funding, and implementation partners, there is need to build capacity among relevant stakeholders, to facilitate partnerships, further the digitisation of agricultural systems, and catalyse funding.

As value chain and support actors explore the proposed recommendations, it will be important to consider some key questions in parallel. These questions serve to both highlight the breadth of exploration and analysis that can be done beyond the scope of this study, and to represent the constraints that need to be reckoned with in aiming for better data sovereignty and governance in agricultural value chains especially within LMICs:

- **What are the specific data opportunities in local agricultural value chains?** For any target ecosystem for intervention, there is a critical need to understand at a granular level the: (i) "what" (types of data generated), (ii) "how" (sources of data i.e., supporting technologies and related functionalities e.g., data portability), (iii) "who" (creators, collectors, and/or controllers), and (iv) "why" (purposes of data generation, sharing, and control). Understanding how the data opportunities manifest on the ground will give stakeholders a practical sense of how exactly data sovereignty can create tangible value for farmers and enable better redistribution of that value, thus allowing support actors to more effectively focus their resources.

- **What is the nature of demand among smallholder farmers in LMICs?** This study revealed that while an increasing number of private, public, and development actors recognise data sovereignty as an important issue, it is not yet an explicit need expressed by smallholder farmers in LMICs. Careful thought must be given to the incentives for farmers to become equal champions and adopters of data sovereignty solutions and how they directly tie back to productivity. Trust will be a key driver of uptake, both in terms of the level of trust that farmers have in providers but also in the trust that the broader ecosystem has in the integrity of the data collected, i.e., that the data creators do not have competing interests. For example, if farmers are sharing data on good farming practices for a potential monetary reward, the data should ideally be collected or certified by a third party. Conversely, where data may reveal agricultural malpractices by smallholders, solutions should seek to address the malpractices without excessively penalising the farmers and discouraging them from sharing their data. Gender differences in demand should also be considered given the gender disparities in digital and data access, which may further increase the gender gap if not accounted for.

- **What does a viable business model or path to sustainability look like?** As outlined earlier, there are different trade-offs to optimise for in balancing between data sovereignty and innovation in the sector. On a broader level, it is important to design for the longevity of data sovereignty interventions to avoid prolonged reliance on public or donor support. This raises the critical question of what the right primary channel or medium is — whether individual or organisational — to control and steward the data. It is important to understand what it would take to build and scale data sovereignty in line with the maturity of the enabling environment, including the roles and responsibilities of different ecosystem actors. Considerations should include options to strengthen the enablers and other infrastructure supporting data sovereignty so as to adequately equip the private sector e.g., far-reaching mobile internet providers, how to adopt a climate lens to avoid adverse effects on the environment in the bid to improve agricultural productivity, and the implications of data sovereignty across the entire life cycle of the data such as opportunities for data reuse.

With this in mind, value chain and support actors would be well-equipped to support the design, piloting, and scaling of viable and sustainable business, technical, and operational models of data sovereignty. The analysis and recommendations detailed in this report offer actionable insight into the enabling role that different stakeholders can play in fostering data sovereignty in agricultural value chains, based on data-driven frameworks and governance models. Given the nascent nature of the topic, continuous dialogue and co-creation with the right ecosystem players is critical to remaining abreast of shifting market perspectives and identifying potential partners and entry points. Many LMIC governments have demonstrated a willingness to regulate the collection and use of data through policy and early enforcement but require strategic partners. This study offers a detailed understanding of the current landscape and market need that is needed to set the pace on data sovereignty, globally and locally.

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9.3. Stakeholder interview list

#	Organisation	Stakeholder category	Interviewee(s)	Interview date
1	Akellobanker	Digital Ag service provider	Jean Onyait Benon Dikan	23.11.2021
2	CGIAR Big Data Platform	Data governance expert	Brian King	02.12.2021
3	Data Village	Data solution provider	Frederic Lebeau	02.12.2021
4	Digital Agri Hub	Ecosystem enabler	Sander Janssen	07.12.2021
5	Digital Green	Digital Ag service provider	Rikin Gandhi Andrew Hicks Vineet Singh	17.11.2021
6	Digital Green (follow-up interview)	Digital Ag service provider	Rikin Gandhi	10.12.2021
7	Enimiro	Agribusiness	David Wright	15.12.2021
8	Eprod Solutions	Digital Ag service provider	Jan Van Casteren	24.11.2021
9	FAO	Development actor	Stuart Tippins	30.11.2021
10	Global Partnership for Sustainable Development Data (GPSDD)	Ecosystem enabler	Martina Barbero	26.11.2021
11	GODAN	Data governance expert / Civil society	Fonteini Zampati	08.12.2021
12	GovLab	Data governance expert	Stefaan Verhulst	14.12.2021
13	Mercy Corps	Development actor	Elias Nure	01.12.2021
14	OpenTEAM	Data governance expert	Dorn Cox	29.11.2021
15	OurSci	Civil society	Dan TerAvest	10.12.2021
16	Solidaridad	Civil society	Han Brouwers	06.12.2021
17	ThinkAg	Civil society	Abhijit Goswami	03.12.2021
18	USAID	Development actor	Josh Woodard	23.11.2021
19	World Bank	Development actor	Marie Agnes Jouanjean	03.12.2021
20	Yara ODX / Varda	Ag service provider	Simone Sala	15.12.2021

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On behalf of the BMZ and as part of the special initiative "One World – No Hunger" (SEWOH), the i4Ag fund identifies and promotes innovations in the agriculture and food sector. The present study was commissioned as part of the i4Ag fund's individual measure "Identification and consultation of innovation proposals".

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