Advancing smallholder agribusiness in Botswana through smart digital innovation

Thorsten Jelinek, Pia Hollenbach, Michael Max Bühler, Loungo Monchusi, SmartBots, Sajid M. Sheikh, Yame Nkgowe, Ron Bakker, Konrad Nübel, and Vasilis Koulolias

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Thorsten Jelinek, Taihe Institute

Pia Hollenbach, University of Lausanne

Michael Max Bühler, University of Applied Sciences Konstanz

Loungo Monchusi, SmartBots, Government of Botswana

Sajid M. Sheikh, University of Botswana

Yame Nkgowe, Sustainable Cities Africa

Ron Bakker, PLP Architect

Konrad Nübel, Technical University of Munich

Vasilis Koulolias, eGovlab, University of Stockholm

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List of Abbreviations

AI	Artificial Intelligence
ALDEP	Arable Land Development Programme
BOCRA	Botswana Communications Regulatory Authority
CAADP	Comprehensive Africa Agricultural Development Programme
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CTA	The Technical Centre for Agricultural and Rural Cooperation
DCS	Digital Connectivity Standards
EU	European Union
FaaS	Farming As A Service
FAO	Food and Agricultural Organisation
FAP	Financial Assistance Policy
FMD	Foot And Mouth Disease
GDP	Gross Domestic Production
GIZ	German International Cooperation
GOB	Government of Botswana
GRI	Global Risk Index
ICT	Information And Communication Technology
IDSA	International Data Space
IFAD	International Fund for Agricultural Development
IoT	Internet Of Things
ITU	International Telecommunication Union
LIMID	Livestock Management and Infrastructure Development
LPWAN	Low-Power Wide Area Network
MP	Members Of Parliament
MOA	Ministry Of Agriculture
NGO	Non-Governmental Organisation
NPD	National Development Plan
NPAD	National Policy for Agricultural Development
SME	Small-Medium Enterprise
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNDRR	United Nations office for Disaster Risk Reduction
UNECA	United Nations Economic Commission for Africa
UNU	United Nations University
UNU-EHS	United Nations University – Institute for Environment and Human Security
WB	World Bank
WEF	World Economic Forum

4IR	Fourth Industrial Revolution

Executive Summary

This research project has been awarded as part of the research competition organized by Connect2Recover, which is a global initiative by the International Telecommunication Union (ITU) with the priority of reinforcing and strengthening the digital infrastructure and ecosystems of developing countries. Carried out by an international and transdisciplinary research consortium, the project sets out to analyze the prospects of digital federation and data sharing within the context of Botswana. Considering the country's stage of economic and digital development, the project team identified Botswana's smallholder agricultural sector as the most important area of digital transformation given the development need of the country's primary sector.

Derived from semi-structured interviews, a focus group, as well as secondary research, the project team developed a digital transformation roadmap based on three development stages: (a) crowdfarming pilot, (b) crowdfarming marketplace, and (c) digital ecosystem for smallholder agriculture. Based on a detailed review of Botswana's smallholder agriculture and the government's digitalization strategy, the report envisions each phase, especially the pilot project, in terms of a minimal viable product. This is to consider the low level of digital penetration of Botswana's primary sector, while providing an incentive to connect smallholders with consumers, traders, and retailers.

The project team has been successful in receiving commitment from actual smallholder farmers, the farmer association and government, as well as support for the idea of developing a crowdfarming marketplace as a novel production model and, eventually, a digital agriculture ecosystem for smallholder farmers, livestock producers, and agricultural technology companies and start-ups. The report is a proposal for a phase-one pilot project with the objective to advance smallholder agribusiness in Botswana.

1 Introduction

Connect2Recover is a global initiative by the ITU, the specialised United Nations agency for information and communication technologies. The aim of the initiative is to reinforce the digital infrastructure and digital ecosystem within countries that have not yet reached a sustainable and sufficient digital environment for all. Connect2Recover covers six regions, with the initial focus on Africa, globally the least connected continent facing multiple and complex impacts of current and future disasters and crises such as COVID-19. With increasing and cascading risks globally, information and communication technology (ICT) has proven to be vital in preparing, mitigating and responding to hazards, crises and risks. Therefore, the Connect2Recover initiative focuses on finding technical solutions to reinforce and strengthen the digital infrastructure and digital ecosystems of beneficiary countries to support the COVID-19 recovery process and efforts and remain resilient in times of natural hazards.

To find innovative and scalable technical solutions to achieve 'Building back better with broadband', the ITU Connect2Recover initiative for the first time organised an international research competition (https://www.itu.int/COMPETITION) with the aim to: (1) improve research focus on digital resiliency and digital inclusion to build back better with broadband for pandemic recovery; (2) build a global research community of think tanks and academic institutions around digital inclusion; and (3) promote knowledge sharing that informs targeted practices to build back better with broadband. 15 Projects have been selected (https://www.itu.int/WINNERS), each were awarded a grant of a value of USD 42,000, from various academic and thematic backgrounds as well geographical origin. The research projects can be considered under three overall thematic categories: (1) Digital Inclusion for Education and Vulnerable Persons; (2) Digital Inclusion for Job Creation and Health; and (3) Digital Connectivity and Resilience. The projects have been introduced in three information sessions during the research competition phase organized by ITU (https://www.itu.int/INFORMATION SESSIONS).

One of the winning project papers (#8) was suggested by an international and transdisciplinary research consortium headed by Prof. Dr. Michael Max Bühler, University of Applied Science Konstanz in Germany titled "Creating a Blueprint for Africa's Transition Towards an Inclusive and Competitive Digital Economy: Identifying Potential Industries, Stakeholders, and Use Cases for the Development of a Federated Digital Platform and Advanced Services with a Focus on Botswana". The project is co-headed by Dr. Thorsten Jelinek, Senior Fellow at the Taihe Institute. In the following sections, the project will be briefly outlined.

1.1 Project summary

Innovative, inclusive, and trustworthy digital economies are based on digital federation that promotes sovereign and secure data exchange. Digital federation promotes new digital services and business models that create an inclusive pathway to lower barriers to entry and systemic challenges, and facilitate the attraction of new, more agile smaller digital players. While lack of internet access, digital skills and literacy remain the key obstacle to Africa's digital transformation efforts, digital sovereignty is about enabling and promoting the generation, sharing and reuse of data, and creating open and trusted data alliances within and across sectors and countries. Such shared data spaces will be essential drivers for a competitive digital economy equipped for cross-border digital trade in knowledge services. They can help economies leverage advanced technologies such as cloud/edge computing, artificial intelligence, knowledge graphs, digital twins, Internet of Things (IoT)/smart sensors, 5G and distributed ledgers. For entire economies, digital sovereignty means to be able to make independent policy and technology choices, deploy strategic digital capacities and infrastructure, and ultimately build an inclusive digital economy based on local, societal needs.

As the reality in many low- to middle-income emerging economies shows, most small digital players have limited resources and usually have no or limited data, so they cannot easily develop and offer their own digital services. In the face of these constraints and limitations, digital sovereignty offers opportunities and possibilities as it lowers the barriers to sharing data and creating digital footprints and encourages the emergence of equitable peer-to-peer platform ecosystems. As part of digital sovereignty, digital federation has evolved into a collaborative framework and technology architecture that enables shared data spaces.

Federated platforms are based on trust, security, and ownership. In a digital federated environment, data can be securely shared and reused in a distributed and interoperable way, while ensuring ownership of the data. Participants in digital federated platforms are simultaneously data owners, providers, consumers, and users. This fact provides a good starting position for collaborative and decentralised digital transformation processes for small digital actors with the aim of creating and improving a digital footprint that enables connectivity to broader and larger digital transformation processes in the long run. It also creates resilient digitalisation connectivity by preventing data monopolisation and provider dependencies.

This report on “Advancing Smallholder Agribusiness in Botswana through Smart Digital Innovation” highlights the potential of federated platforms in the country context of Botswana and how it fits into the country's overall digital transformation strategy (cf. 2.1). It also offers insights into the everyday challenges, obstacles, and limitations of smallholder farmers

("lived realities") who have been identified as potential users for the establishment of a federated platform to connect relevant stakeholders within the agricultural sector in Botswana to better connect and recover from current crises but also to better prepare and mitigate future crises and disasters for an improved resilience (cf. 2.2).

1.2 Report structure and research methodology

After the introduction, chapter 2 will embark on a detailed analysis of Botswana's digital strategy and programs (2.1and 2.2) followed by the presentation of the use case of this research project (cf. 2.3). The former section highlights the government's digitalization priorities of reaching a knowledge-based economy and smart society, the latter one outlines the opportunities and challenges related to small stock farming in Botswana. Insights about everyday challenges and realities as well as specific technological needs and demands will be presented in section 2.3.4. Those insights have been derived from qualitative semi-structured expert interviews reflecting the "lived reality," a focus group experience providing co-design and validation, as well as secondary research related to Botswana's small stock farming and digital development. In section 2.4, the concept of digital federated platforms is introduced as a digital governance framework fostering digital sovereignty, data sharing, and inclusivity. In chapter 3, the project team develops a digital transformation and collaboration roadmap based on the insights presented in chapter 2. The proposed roadmap (3.1) consists of three development phases that are linked as maturity levels: (a) crowdfarming pilot; (b) crowdfarming marketplace; (c) digital ecosystem for smallholder agriculture (cf. 3.1.1-3.1.3). Each phase is outlined in turn with a focus on the first phase of the roadmap, the "Crowdfarming Pilot Project" (cf. 3.2). The research team set out with the assumption that digital federation could foster and incentivise connectivity in Botswana. However, to consider the low level of digital penetration of Botswana's primary sector, the digitalisation and collaboration roadmap is grounded in the idea of delivering a minimal viable product. Thus, three phases of operationally launching a minimal crowdfarming marketplace are proposed. The research report concludes with a set of recommendations and proposes the initial phase of the roadmap as a follow-on project (chapter 4).

2 Context Analysis and Use Case: Federated Platform for Small Stock Farming in Botswana

2.1 Meandering between Fourth Industrial Revolution and connectivity challenges

The Republic of Botswana is a landlocked country in the Southern Hemisphere, bordering South Africa, Namibia, Zambia, and Zimbabwe. Botswana is known as one of the most sparsely populated countries in the world, with an estimated population of about 2.3 million people spread over an area of 581,730km^2. The country is topographically flat and 70% covered by the Kalahari Desert, which increases the challenges of governance and equitable access to adequate health, economic, security, water, and electricity infrastructure. Apart from these challenges, since independence on 30 September 1966, Botswana has gone from being one of the poorest countries in the world to a middle-income country with a UN Human Development Index of 0.735[1]. In 40 years (1980-2020), Botswana has drastically reduced poverty from over 50% to 17%, increased per capita income from US$2,000 to US$6,525, and increased school enrolment from 20% to over 80%. (UN Botswana 2020) Although the country has made tremendous progress, it continues to lag in gender equality. Women face high unemployment rates and limited access to land and housing. This makes women a risk group for poverty and other multi-layered vulnerabilities – social, economic, and political. Furthermore, women are overrepresented in the informal economy: they operate and own over 74% of informal businesses in Botswana. This means that women are structurally excluded from labour and social security protection, including long-term benefits such as pensions.

The country's success story is primarily based on its mineral wealth. Being one of the most stable democracies in Africa with sound economic policies and strong macroeconomic foundations, Botswana has been able to make good use of the revenues from the diamond mines, which has contributed to building the country's infrastructure and stable economic growth. However, economic stability is at risk as economic diversity is not yet balanced. After the discovery of diamonds, "the structure of the economy may ... be simplified to the mining and non-mining export sectors, coupled with the domestic sectors comprising government and goods and services for domestic consumption..." (UN Botswana 2020). This limited diversification of the economy – mining, government and domestic market for goods and services – puts Botswana at high risk of economic crises, especially in times such as the global COVID-19 pandemic. On the other hand, the INFORM Global Risk Index (GRI) score of 3.2[2], which considers exposure to hazards – e.g., drought, floods, torrential rains – lack of institutional

[1] The score puts Botswana in the high Human Development category, positing it at 100 out of 189. It steadily improved from a HDI score of 0,573 in 1990 to its latest score of 0,735. (Source: https://hdr.undp.org/en/content/latest-human-development-index-ranking)

[2] INFORM - DRMKC

and infrastructural capacity to address risks, and socio-economic vulnerability scores, shows a very low overall risk of humanitarian crises and disasters. Inequality and droughts are the country's biggest risk factors, as evidenced by the fact that Botswana is one of the five most water-scarce countries in the world, which is significant in the case of the proposed minimum viable product in the agricultural sector – A Federated Platform for Small Stock Farming.

2.2 Towards a knowledge-based economy and smart society

To further diversify Botswana's economy, the government is taking steps to exploit the multiple opportunities offered by the Fourth Industrial Revolution (4IR). Although advanced IT applications and the use of the 4IR are still limited to a few private and public enterprises and sectors of the economy, there are several segments where innovative and new technologies are flourishing, e.g. in the inter/transnational business segments of the banking sector, mining and diamond mining, retail and well-established agricultural businesses.

In line with the Botswana Vision 2036, which aims to transform Botswana from a middle-income country to a high-income country by 2036, several activities have been implemented in recent years (Vision 2036). A forum on 4IR was held at the Gaborone International Convention Centre in August 2019 to provide a platform for the public and private sectors to assess Botswana's readiness to participate in 4IR, discuss opportunities for collaboration among stakeholders and set a development agenda. A visioning workshop organised by the Ministry of Investment, Trade and Industry and UNCTAD in May 2019 aimed to develop an e-commerce strategy for Botswana: "By 2026, we will harness the power of our private sector, the talents and skills of the people of Botswana, our mastery of ICT and our dynamic e-commerce sector to make our products and services a globally recognised brand for Botswana." (UNCTAD 2021: 20) After a pause enforced by the COVID-19, the Engineering Registration Board in Botswana held an Engineering Forum in March 2022, which called for reflection on how creative engineering value chains support progress towards a 4IR in Botswana. The Botswana Communications Regulatory Authority (BOCRA) also continues to publish various discussion papers and documents that highlight persistent challenges, constraints, gaps and misalignments between Botswana's vision of 4IR for all and the existing day-to-day struggles to achieve stable and inclusive access to digital transformation and connectivity. BOCRA therefore proposes a development framework for the transition to and adoption of 4IR technologies in Botswana[3].

Among the numerous activities of various public, private, bilateral, and multilateral stakeholders and the many goals and visions set by the Government of Botswana (GoB), the GoB has

[3] BOCRA Broadband Facts and Figures , BOCRA e-communicator

not yet signed or approved a public document that fleshes out a comprehensive approach to an official pathway for Botswana 4IR. However, the following documents and guidelines provide specifications to be considered in the establishment and implementation of the pilot project of a federal platform for smallholder farmers:

2.2.1 Botswana Parliament ICT Master Plan

Alongside the executive and the judiciary, Parliament, as a legislative body, is the third pillar of stable democratic government. To support the effectiveness of Parliament and its members, Botswana has developed a strategy for an ICT Master Plan[4] in 2012 that outlines how core institutional functions can support the work of Parliament. The following is proposed:

i. Development of ICT policy governing issues such as usage of information systems, security and privacy policies, establishment of ICT committee, maintenance plans, and budgeting
ii. Ensuring that parliament has adequate computer infrastructure to support its activities, such as networking, PCs, video conferencing, and software
iii. Strengthen Parliament's information and knowledge infrastructure
iv. Strengthen Members of Parliament (MP)'s involvement in ICT for community development activities
v. Strengthen MP's capacity and advocacy for e-government, e-governance, and e-democracy, and develop strategies to raise awareness within parliaments on the practical benefits of e-government, e-governance, e-voting, and e-democracy
vi. Enhance inter-parliamentary cooperation, collaboration, and knowledge-sharing through use of appropriate technology.

2.2.2 Vision 2036

Vision 2036[5] from 2016 was prepared by the presidential working group "Vision 2036". It is a transformation agenda that defines the aspirations and goals of the country as a people. The main goal is to achieve "prosperity for all" and leave no one behind. The document lays out the fundamental changes needed in policies, institutions, and mindset to transform Botswana's mineral-based economy into one based on competitiveness, productivity, efficiency, and openness to the world.

Vision 2036 attaches great importance to the ICT sector as it contributes significantly to the economy by enabling the delivery of efficient products and services across all sectors of the

[4] Parliament of Botswana ICT Master Plan
[5] Botswana Visions 2036

economy, including the delivery of government services (e-governance). Vision 2036 is based on four pillars:

Table 1: The four pillars of Vision 2036

PILLAR		REQUIREMENTS
PILLAR 1	Sustainable Economic Development	4IR innovative projects and applications for all economic sectors; target commercialization and internationalization of economy; professionalize human capital for 4IR
PILLAR 2	Human and Social Development	knowledge and a knowledge-based economy needs 4IR related skills; knowledge is most critical factor using ICT and digital technologies for all, especially with threats of cybercrime
PILLAR 3	Sustainable Environment	4IR implementations for monitoring environments: water quality, use and waste; electricity uses and savings; waste management; climate resilience; sustainable land use and management; sustainable housing; and efficient ecosystem services
PILLAR 4	Governance, Peace and Security	4IR technologies to implement innovation and efficient services to all in the country (e-governance, e-security, decentralization of power)

2.2.3 National Development Plan 11

The National Development Plan[6] (NDP) 11 of 2017 identified several challenges such as high cost of ICT services, slow implementation of e-government programmes and limited citizen participation and empowerment. NPD 11 is currently being revised and will transition into NPD 12, which will address current pathways, lessons learnt and next steps for digital improvement for all. The NPD11 includes the following points related to ICT and data:

- To put measures in place to ensure that ICT will continue to play a pivotal role in the development and diversification of the economy
- It emphasizes the importance of access and use of information through modern technology

[6] National Development Plan 11 - Botswana

- The importance of achieving the goal of universal access to reliable high-speed networks, to improve competitiveness and attractiveness to domestic and foreign investors, as well as the public
- Accessibility and Affordability to broadband connectivity that will lead to access to information and enable innovation among businesses and individuals by providing a platform that supports entrepreneurial advancement, access to information and services, and active citizen participation in the information society
- Emphasis on development of effective e-services and e-Government projects. The effective use of ICT is projected to boost productivity and growth rates in technology driven sectors, such as Communications, Finance and Business Services, Trade, Hotels and Restaurants, Mining and Manufacturing (EU Africa Rise; SmartBots).

2.2.4 Data Protection Act

The Data Protection Act[7] came into force on 15 October 2021 and is designed to ensure privacy, confidentiality, and availability of data in Botswana. The Act defines what is meant by personal data and outlines the rights and obligations of parties involved in the processing of personal data – including the data subject, the controller, and the data processor. It also establishes the Information and Data Protection Commission ("the Commission"), which is responsible for the effective application of the Data Protection Act after its entry into force.

2.2.5 National Broadband Strategy

The 2018 National Broadband Strategy[8] in Botswana aims to develop a coordinated approach to ensure that reliable high-speed networks are accessible throughout the country and, over time, to ensure equitable and affordable access to broadband infrastructure and services for all. The strategy has three main objectives: (1) creating an enabling environment for the deployment, accessibility, availability and use of broadband infrastructure and services; (2) ensuring universal access to broadband services through the development of appropriate financing mechanisms that include public-private partnerships or targeted subsidies; and (3) facilitating and promoting economic diversification.

2.2.6 Smart Botswana Strategy

The theme of this strategy is to aim "Towards Digital Transformation for Botswana" (SmartBots)[9]. The document addresses Strategic Initiatives, Priority Setting with an Implementation Plan for the period 2020-2022. It is Botswana's new proposition to drive transformation across

[7] Data Protection Act - Botswana 2018
[8] National Broadband Strategy
[9] Smart Botswana Strategy

the economy, government and society is an action plan aiming to create a smart, sustainable society for Botswana. Services to be developed under SmartBots include:

- Electronic Procurement
- Electronic Identity
- Electronic Payments
- Electronic Tax Revenue Collections
- Electronic Land Registrations
- Electronic Licencing and Vehicle Registration

The strategy highlights the importance of building a national cloud computing infrastructure that supports data sovereignty and Big Data analytics. It supports the idea of fully supported digital start-up packages for SMEs that include e-commerce platforms, emails, accounting packages, websites and others. It also underlines the importance of national training in digital literacy.

There are digital connectivity standards for villages in Botswana, proposed by the Ministry of Presidential Affairs, Governance and Public Administration and coordinated by the Botswana Communications Regulatory Authority (BOCRA). The focus is on the importance of infrastructure for all and digital connectivity standards (DCS) for villages so that ministries, government agencies and parastatals can implement their connectivity projects in line with SmartBots. This digital connectivity project includes the expansion of backhaul internet infrastructure and last mile connectivity to facilities in villages such as Kgotlas, health facilities, youth centres, ministries and departments, and schools.

2.2.7 National Cybersecurity Strategy

Technology and ICT are used in many sectors in the country and efficiency is increased through the use of relevant and effective technology. With the use of technology also comes threats, such as cyber security risks. The 4IR, which includes technologies such as the Internet of Things and Big Data, relies on the use of cyberspace to enable intelligent systems to communicate with each other and with people. It is therefore important for Botswana to mitigate the risks associated with cyberspace if the country is to realise the full potential of the 4IR. For this reason, Botswana adopted a National Cybersecurity Strategy[10] in 2021 to ensure that security is an integral part of IT systems development and that the people of Botswana are educated and sensitised about the risks associated with cyberspace.

[10] National Cybersecurity Strategy

Government's efforts to digitally transform all sectors are confronted with a contrasting reality of life, especially for most citizens in the rural areas of the country who still face major challenges when it comes to constant availability and connectivity to advanced and digital technologies. The proposed use case for the implementation of a pilot project of a federated small livestock platform will therefore be an important example.

2.3 The story from below: small stock farming in Botswana

The agricultural sector accounts for only 2.1% of Botswana's GDP in 2020 (Statistics Botswana 2021), but employs 20.4% of the working population, providing more jobs than the industrial sector (Statistics Botswana 2019; Seleka and Lekobane 2017). Agriculture is vital for about 70% of the country's citizens, who mainly engage in subsistence farming, and provides food, income and informal employment, especially for people in rural and peri-urban areas (UNECA 2018; IFAD 2016, 2020). Although the agricultural sector provides livelihoods for most rural dwellers, its poor performance has led to a decline in real wages compared to other sectors such as services or manufacturing, leaving many people extremely vulnerable and exposed to multiple risks at different levels. In the context of livestock production in Botswana, risks are defined as exposure to adverse and extreme weather conditions, input and output (market) uncertainties, institutional and political/police uncertainties and livestock disease epidemics.

Increasing pressure on resources, climate change-related risks, as indicated by the World Resource Institute (WRI) Updated Global Water Risk Atlas of Water Stressed Countries and States Report 2019, which places Botswana in the top 10 extremely water-stressed countries worldwide, and the dominance of traditional farming methods are the main factors leading to the overall low agricultural production in Botswana (Temoso et al. 2021; Bahta and Baker 2015). FAO (2021) noted that food insecurity in Botswana is increasing and persisting due to the impact of COVID-19. These systemic and cascading risks continue to grow and increase vulnerability.

As the Kalahari Desert covers 70 % of Botswana's land area and the soil is very poor, agricultural activities are geographically very limited. In addition, the semi-arid climate with low, highly variable and unevenly distributed annual rainfall between 250 and 500mm does not provide favourable growing conditions. Therefore, there is a clear preference for livestock over crop production. Crop production is dominated by cereals, but is limited by the restricted productivity, which is mainly reflected in the insufficient water supply. The three main cereals are sorghum, maize and millet. Horticultural production, consisting mainly of potatoes, tomatoes, cabbage and oranges, is concentrated in the south-east of the country. The predominant

agricultural activity is livestock, which occupies up to 70-72% of the cultivated land (Moreki et al 2021; Statistics Botswana 2012, 2018).

2.3.1 Small livestock farming as exemplary for small scale farming

Livestock dominates the agricultural sector in Botswana, contributing to 80% of total agricultural GDP. Beef production plays the largest role in the livestock sector (57% share) and is the most important agricultural export product, including pasture-raised beef for EU markets. However, given the high prevalence of animal diseases – especially foot-and-mouth disease (FMD) – this export market is fragile and volatile, as only meat from non-vaccinated animals can be used (CAADP and WB 2015). Overall, production in the livestock sector exceeds national consumption and demand and is therefore targeted for export to new markets. Beef is followed by small ruminants - goats and sheep, which have adapted mainly to the harsh climatic conditions in the country but continue to decline due to numerous challenges such as (1) production, (2) technical equipment, (3) financial resources and stability, (4) market accessibility, (5) general infrastructure and (6) animal disease control (Statistics Botswana 2019; Bahta and Malope 2014; Moreki et al 2021).

The livestock sector is divided into commercial and traditional/community farming, with the latter dominating especially in rural areas. Limited access to roads, electricity, grain storage and adequate sanitation facilities mean that traditional farming is most feasible and suitable in an inadequate infrastructural setting. The characteristic features of the existing farming systems are: (1) the type of land tenure; (2) the level of market integration, access and knowledge; and (3) the level of technology, capital and resources used.

Commercial livestock operations grant their owners the exclusive right to graze and are characterised by fenced operations with owned and leased land. Commercial farms operate on owned, leased or tribal grazing land (Tribal Grazing Land Policy, TGLP) or ranches. The common practice of commercial livestock operations is to keep livestock in fenced pastures or ranches, supplement feeding to improve productivity and health, and manage rearing well (Macala et al. 1989; Barnes at al. 2008). Although commercial livestock farms keep fewer animals overall (about 14%), they operate more efficiently, i.e. offtake rates[11], birth rates and mortality rates are better, making the sector more profitable overall and producing exclusively for the market.

In contrast, in traditional livestock management, animals and herds are kept on communal/tribal grazing land, with livestock owners having no ownership rights over grazing resources. Animals mostly graze on open rangelands and rely on natural pastures during the

[11] Offtake rate defined as the proportion of animals sold in a year

rainy and dry seasons, with no supplementary feeding practiced and limited fencing. Traditional agriculture is characterised by informal, low-skilled labour, small livestock and limited resources, and produces mainly for subsistence (Morekti et al. 2021). Farmers who regularly use communal land produce for household and market consumption. Traditional livestock farmers are more exposed to risks and highly vulnerable to external and internal shocks, as they have less access to financial resources, credit and assets that can protect them from crises.

2.3.2 Women in the agricultural sector

There is a clear gender split in the agricultural sector, with more women involved in crop production, justified by the fact that more women (47%) own arable land than men (41%). However, in most cases it is men who have full access, ownership and control over land and other valuable agricultural resources such as water resources, credit/finance, information, markets, technology and agricultural support services. Livestock farming is predominantly done by men (about 70%) and less by women (about 30%), with more women keeping small ruminants (goats and sheep), indigenous chickens and other livestock, and men keeping large livestock (cattle).

Although Botswana's agricultural policy is committed to promoting the development of marketing and commodity value chains, a well-developed value chain analysis is lacking. The different types of market systems include: (1) formal organised markets such as the Botswana Agricultural Marketing Board (BAMB), (2) livestock markets, (3) rural produce markets, (4) cooperative markets, (5) sales markets and (6) hawking. Nevertheless, data on the gendered agricultural value chain is lacking in Botswana, mainly because women are predominantly involved in informal markets selling various commodities. Even though data is lacking, it can be said that there is an over-concentration of market power by a small number of farmers, the majority of whom are not only foreign but also predominantly white male commercial farmers (FAO 2018). The majority of street vendors and hawkers selling food and horticultural products, among others, are women who are informal petty traders doing business in an unstructured, often informal way, with the majority having no formal training and/or education and limited access to the resources necessary to make their trade sustainable or scalable. The development of pro-poor value chains that also take into account the specific needs of rural women will therefore address, on the one hand, the constraints faced by the poor and, on the other hand, incorporate the particular additional constraints faced by women due to gender specificities.

Women farmers need specific inclusive initiatives that enable them to access value chains to generate greater financial returns for their farms. Therefore, it is important to provide access

to extension services and innovative empowerment initiatives that address knowledge, training and capacity building in addition to technological advances. A broad knowledge of the market(s) will improve market intelligence that will enable access to price information, participation in markets and innovation in appropriate financing. It will also improve the overall resilience and sustainability of agricultural activities.

2.3.3 Government support improving agricultural sector efforts

Since independence, the government has implemented several policies and support programmes to guide, boost and improve the production and productivity of various agricultural sub-sectors (Seleka, 1999; Sigwele and Orlowski 2015). Agricultural policies have focused on providing adequate and secure livelihoods, increasing agricultural production and productivity, achieving food self-sufficiency, conserving agricultural land resources, and meeting the employment needs of a growing labour force (Ministry of Agriculture 1991). The challenge is to become more innovative and use modern techniques such as improved animal husbandry and irrigation to increase productivity.

In 1991, the government introduced the National Policy for Agricultural Development (NPAD), which emphasised a comprehensive food security strategy to ensure that all households have access to adequate and sufficient food. Several programmes were developed under the NPAD, including the Arable Land Development Programme II (ALDEP II 1991), the Accelerated Rainfed Arable Programme (ARAP), the Irrigation and Water Development Project, the Dairy Improvement Project and a number of other agricultural projects funded under the Financial Assistance Policy (FAP) (MoA, 2002). In the livestock sector, policy initiatives included subsidised borehole drilling, ranch management programmes, artificial insemination, veterinary services and post-drought restocking. However, the most important measure for the livestock sector was introduced in 2007, namely the Livestock Management and Infrastructure Development (LIMID) programme, which was renamed LIMID II in 2010 (MoA 2010). The objective and overall purpose clearly focused on improving cattle, small livestock and chicken productivity, livestock management and improving the use and conservation of pasture resources. To protect livestock from animal diseases, the government has implemented the Foot and Mouth Disease (FMD) Control Project and expanded the FMD-free zones since 1994. FMD usually occurs in areas where there is interaction between wild animals and livestock, which increases the risk of transmission through infected wild animals. Disease control is of great importance as it minimises the risk of losses and costs, but also improves access to international markets (GoB 2018).

Another important backbone for government support to the agricultural sector and its continued growth efforts are extension services. Agricultural extension officers form a link between

research and farmers by providing support in decision-making through offering information on sustainable farming practices and biodiversity, and furthermore, by propagating new, and more effective farming methods based on the latest innovative research. Agricultural extension remains one of the most effective strategies for rural development – no growth without effective extension (Anaeto et al. 2012). Botswana is divided into different extension areas where extension staff are stationed to be closer to farmers[12], other relevant stakeholders (international/national) and district departments/services of the Ministry of Agriculture (MoA) – District Agriculture Coordinator, Veterinary Services Department, Livestock Production Department, Livestock Services Technical Assistant, Crop Services Technical Assistant, Agricultural Research Department. To achieve stable, steady and increasing productivity, it is important, in addition to the introduction and transfer of new advanced technologies, to train and learn appropriate skills – marketing, management, decision making, product diversification, etc. – facilitate agricultural associations and farm groups, and increase the accessibility and attractiveness of the market. Therefore, extension workers need to bridge the gap between farmers, extension services and the agricultural policy context.

2.3.4 Voices from within: profile of small livestock farming

In addition to secondary research, the project team collected "voices from within". This approach supports the verification of the secondary research and helps to get a clear understanding and picture of the lived reality of smallholder farmers – their challenges, demands and needs in relation to the digital transformation in Botswana. Knowledge and insights were gathered through semi-structured qualitative interviews during the project period. We decided to have a pre-selected set of open questions to outline similar structures of the interviews and to secure a minimum of comparable questions. Overall, the questions were chosen to be very open to create an open exchange and interview space, and thus, were not limited. The questions were chosen based on primary research analysis and to trigger conversations on the identified obstacles from primary research, but were not exclusive and conversations ended up discussing issues beyond the pre-selected questions (see Appendix 6.3). During the project phase four (4) online interviews and eight (8) face-to-face in-depth interviews were conducted in Botswana. Farmers were selected based on their status in agriculture: (a) trying to enter the market and become commercial, (b) commercial but facing challenges to survive, and (c) commercial and successful. Furthermore, interview partners were selected to cover geographical diversity and different administrative districts: (1) close to the urban environment of Gaborone – South-East District; (2) Southern District; (3) Kweneng District; and (4) Central

[12] one extension officer is responsible for 300-400 farmers based on size of farming population in one division (CAADP and WB 2015)

District. The sample size relates to the fact of accessibility and availability of smallholder farmers and through balancing and counter-verification through farm associations and other relevant stakeholders from Ministries and extension officers, the statements and findings; therefore, well represented the small holder farming sector.

In addition, on 23 May 2022, the project team organised a co-creative online session entitled: "Innovation Solutions Meeting in Digital Small Agriculture", which was attended by 15 people from research, practice and farmer organisations. The objective was twofold: (1) to review the identified challenges of smallholder farmers and (2) to select the most promising and scalable use/business case with the greatest potential to create value for society – namely smallholder farmers in Botswana. Below, we let the voices have their say, describing the current struggles, day-to-day challenges, technological needs and requirements, but also the added value for implementing a federated platform that supports the long-term development of predominantly rural life/agricultural realities and accelerates the digital transformation for the most vulnerable, marginalised and risk-prone members of society in Botswana. The co-creative workshop confirmed the existing socio-economic, business and technological challenges, which are detailed below.

The following sections will summarize and highlight the outcome of individual interviews and the co-creative online workshop. As the online workshop included brief presentations on challenges from participants, both are summarized herewith.

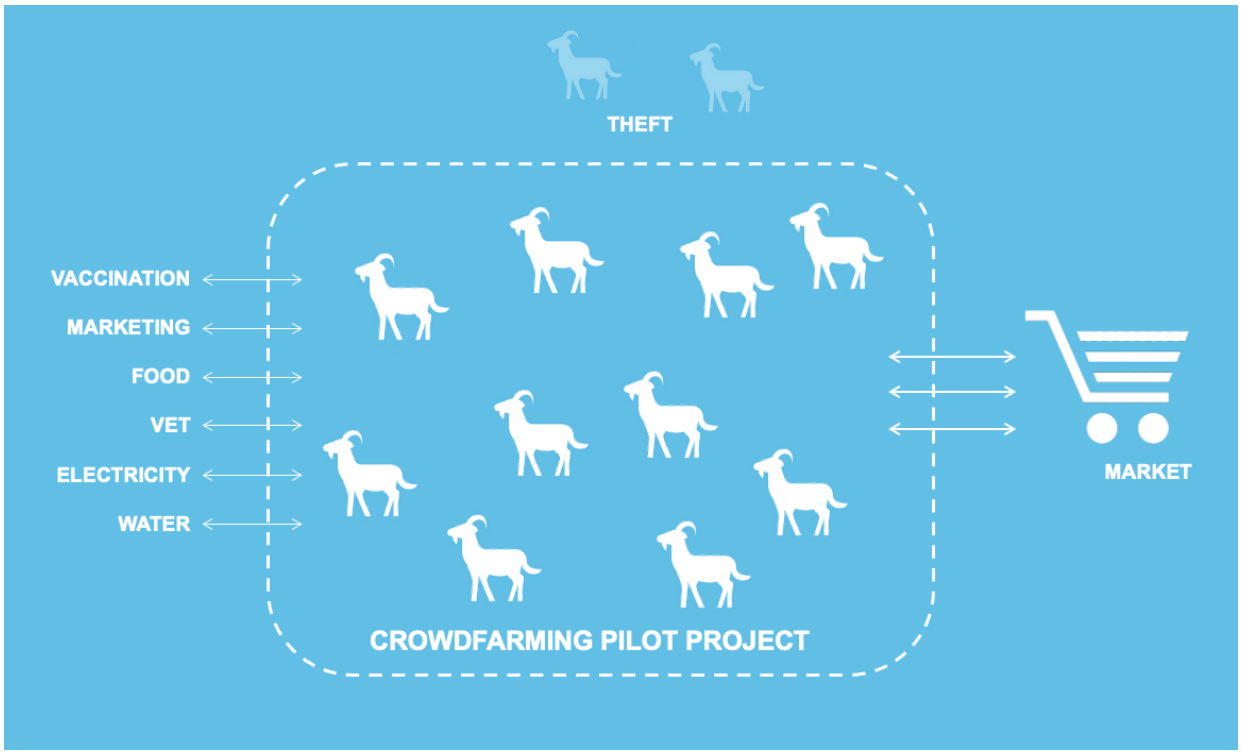

Figure 1: Current challenges of smallholder agricultural sector in Botswana
Note: Authors' own illustration (2022)

A. Insights from everyday challenges and realities

Interviews were conducted with farmers involved in the continuity of traditional small-scale livestock farming, in transition and aspiring to commercial farming, as well as in commercial farming, to get a 360° view of the reality of farming practices and facilities. The challenges differ not only in the fact that fenced (commercial) and open (traditional) pastoralism carry a higher risk in terms of animal losses, animal tracking, animal surveillance and theft. Therefore, the vulnerability and cascading risks of traditional agriculture in relation to disasters are undoubtedly higher, and technological but especially infrastructural improvements will strengthen resilience enormously. In the following, we highlight the most pressing problems that increase current risks and back this up with selected statements from farmers' everyday lives; often the statements refer to several problems, as they are often interconnected and self-reinforcing. We did choose to summarize the challenges under 10 categories and provide space to let the farmers speak directly through statements to provide better and more authentic insights. In addition, the in-depth view(s) were expanded through in-depth interviews with researchers, members of farmers' organisations, technicians associated with agriculture and political actors.

Table 2: Everyday challenges of small-scale livestock farming

Challenge	Selected Statements
Electricity – existing / stable connection	*"There is no electricity… there are some solar lights, but not yet developed well and costs are too high…diesel generators support water pipes…"* *"Electricity is a problem; it is necessary for cold chains for meat and medicine, but it is not secured…we use diesel generators and solar lights"* *"Electricity is for security - of workers and animals"* *"Access to electricity is improved product quality and value chain"* *"One thing that is critical is electricity…the areas we farm are very remote…solar systems e.g. for refrigerators can help to minimize driving costs…"* *"No electricity, means no connection, means no communication between farm owner and farm worker… that is a problem"*
Water availability (climate change)	*"…rainwater is not securely available due to changing climate, we have to drill boreholes…its more difficult to monitor…it's more expensive using diesel generators and solar systems"*

Challenge	Selected Statements
Animal Health and Diseases	*"…distance to animals is very high…I am 160km away…it is difficult to recognise problems in time, e.g., when it comes to diseases…"* *"…if animals are sick you cannot reach in time to provide medication and health care…farm workers are with a sick or dead animal they cannot call or send a picture and we can monitor from afar…we have to drive there, this is challenging and inefficient as accessibility and road infrastructure is limited"* *"If animals are sick you need to react directly…they can recover if you give right medications and vaccinations, it's possible…but well-educated farm workers are limited…"* *"Fenced farming is less risky as tracking is guaranteed, still you have to monitor daily the health of animals…"*
Vaccination	*"Vaccination is critical, it needs to be done once a year…important vaccine needs close monitoring on cold chain and how to inject…"* *"Veterinary offices are not often close; some are not regularly occupied…number of farmers is high and very widespread…coverage of officers is limited…support for regular vaccination is limited"*
Communication / Connectivity	*"…internet connectivity is very poor, there are some spots where there is no internet available…"* *"Extension officers cover a large area and miss decent work equipment…sometimes you call, and they cannot come because they have no car…"* *"Communication is working through phone calls…but connectivity is weak…farm workers need to find spots to have connectivity..."* *"Connectivity and network are not always accessible… there are some hot points you have coverage"* *"Infrastructure is bad, you can only use a 4x4, if it rains or is dry it is not easily accessible…"* *"Cattle is grazing freely on community land…if you look for your animals, it is difficult to connect with others to find them…even if you have farm workers with good phones…they cannot send pictures of animals or contact you as connectivity is not there, no coverage…"* *"…farming is dangerous due to limited infrastructure as light, water, roads…and wildlife encounters"*

Challenge	Selected Statements
Animal Theft	*"Human threat is huge due to animal thievery…on fenced farms there is less risk but in grazing farming land, it increases"*
Farm Management	*"Technology can support by providing better knowledge of the movements of animals, the amount of water they consume, their feeding and grazing habits… this way I can improve my farming, pump water for example only when needed…overall management and efficiency improves"* *"Knowledge and information sources need to be improved … data for better farm management"* *"No reliable data available on farming capacity nor farming activities – enlarged data will help to forecast and manage better"* *"Data on animals needs to be seen as profit"*
Land accessibility and availability – needed land reforms	*"I cannot grow bigger in farming and go commercial because I have no access to land and have no land rights…my request for more land was in 1979, I still have not got it…"* *"Land management is important…we have only limited land for grazing, and we need to keep numbers in balance with land…"* *"Land reform is needed, we cannot grow due to land restrictions, access rights to water…"* *"Farming on communal land (traditional farming) is restricted and hindered from going commercial"* *"Production and farm expansion /growth is limited due to limited land access"*
Marketing and Market access	*"Secured and guaranteed throughput will improve the profit for farming…better planning for all value chains"* *"Big traders hinder access to markets for small livestock farmers as they cannot meet purchase quantity"* *"Traditional farming stock is less valuable due to castration; breeding stock is higher value…"*
Control of Market Price	*"Major challenge is the supply chain of the product and the appreciation of the value of farm products by buyers…supply chain needs to be more efficient and targeted…"* *"The market has to change – the buyer should not dictate the price for your product!"* *"Slaughter auctions improve the fairness of prices"*

B. Technology needs and demands

Table 3: Technology needs and demands

Needs	Selected Statements
Animal Tracking / Monitoring	*"Keeping track of animal is important, they give birth anywhere or get sick and we do not know…if technology can help us to track on the health, their temperature, their weight, anything we need to monitor better the animals to improve value…if technology can help me to know, to track that I know when I am not there…"* *"…animals can be tracked is the corner stone, if the animals are tracked you are confident to attend to the animals that are there…you do not have to assume, you know…you keep stock of where they are and how they are…you can track if they come in or out of the kraal…so I know they are there…If one is not there I know and know when it was there last…"* *"Animal tracking is very costly…question whom to track – herd or individual animal?"* *"Microchips are low costs, but primary investment and surrounding technology is high investment – not possible for small livestock farmers"*
Electronic Ear Tagging	*"Ear Tags do not help; they do not help us to track the animals…its only about registration…"* *"Ear tacks are not electronic yet …support better monitoring"* *"Ear Tag gives information on the animals' history – breed, birth, vaccination, sickness history – and status… we use old fashion technology to manually integrate everything in a datasheet…"*
Remote Farm Monitoring	*"We use technology via smartphones, farmworkers take pictures of sick animals, and we can give remote advice, or we send pictures to vet who can advise"* *"Thinking to implement a drone system of cameras for monitoring and having an overview what is happening…if we do not use the technology the costs for driving there will remain…but the problem is the technology is not accessible for many small-scale farmers, it is currently too expansive…"*

Needs	Selected Statements
Animal Temperature checking for Animal health and Breeding	*"Microchip within animals to trace and monitor – animals' history is stored and transferred into management system…data needed to access international markets…"* *"Technology needs to improve in artificial insemination, semen storage, embryo transplant…"*
Farm Management	*"More data on animal situation will help us to improve, to learn and manage more efficiently…"* *"Success of agriculture is based on a holistic approach – the case of water needs to be approached, the case of electricity, of land accessibility, and sanitation…we need toilets for the farm workers in the bush so they stop contaminating… all things have to be addresses holistically… there is nothing we can do without technology…technology needs to be solved…I need to track my animals, I need to know how many animals I have day by day, how many come in and out of the kraal…you know, today I have not seen some of my animals for the past three month…innovation is very, very important…to improve the operations in the remote areas…"* *"In Botswana farming needs to be treated like a business, not something we sustain through our pockets…it is not sustainable…it has to be managed efficiently and risks need to be minimized"*
Access to market	*"For Marketing we use Facebook and Instagram, and it also supports communication with costumers… it is worldwide the fastest communication and networking tool…we also share training and experiences, and so other farmers can learn…its always possible to contact us via email, Facebook, Instagram, phone or WhatsApp…that aspect of technology has improved and made communication much easier…"* *"Technology can support direct access to markets, to cut out middleman, and provide necessary market information"* *"Improve direct marketing of farm products – crowd marketing and/or cooperative farming through platform technology"* *"Connect farmers to meet market demands – cooperatives… technology for farmer connectiveness"*
Vaccination	*"Vaccination monitoring is essential, but so far there is no electronic solution…all is via handwritten tables…"*

Needs	Selected Statements
Connectivity	*"Most important for small-scale farmers is accessibility to technology and acquisition prices…"* *"Access to internet is very critical, we cannot live without internet these days…a passionate farmer needs access to internet to learn, to exchange and to better knowledge…we need to exchange with each other, with extension officers, with veterinarians to improve together…technology is the cornerstone for us…"*

Overall, the studies and farmers' profile show that technology and connectivity improvements need to be cost-effective and easily accessible in the reality of rural, marginalised and infrastructurally underdeveloped regions. It is also becoming clear that technology, data collection and access, knowledge sharing, and connectivity are necessary to improve the overall resilience of farming activities themselves, thus creating a strong pathway for the sustainable development of small-scale pastoralists and their close socio-economic environment. New technologies such as federated platforms offer small-scale livestock farmers the opportunity to create a digital footprint to collect relevant data that will form the basis for knowledge and thus improve profitability and production.

2.4 The Story from above: digital federated platforms

While the lack of electricity, internet access, digital skills and literacy remain the critical obstacle to Africa's digital transformation efforts, Africa's emerging digital economy presents its own development challenges in the context of rapid global digital transformation. In this context, digital sovereignty has emerged as a promising governance approach to ensure that the digital economy is innovative, inclusive, and trustworthy. Digital sovereignty is about enabling and promoting the generation, sharing and reuse of data, and creating open and trusted data alliances within and across industries and countries. Such shared data spaces will be key drivers for a competitive digital economy. They can help economies leverage advanced technologies such as cloud/edge computing, artificial intelligence, knowledge graphs, digital twins, Internet of Things (IoT)/smart sensors, 5G and distributed ledgers. Most small digital actors from business (start-ups and SMEs), civil society (citizens, NGOs and academia) and even (local) government have limited resources and usually have no or limited data; therefore, they cannot easily develop and offer their own services. As part of digital sovereignty, digital federation has evolved into a collaborative framework and technology architecture that enables shared data spaces. In a federated digital environment, data can be securely shared and reused in a distributed and interoperable way, while ensuring ownership of the data (Nübel et

al. 2021). As shown in Figure 2, the key participants in a federated digital platform are data owners, providers, consumers, and end-users. Federators do not collect or own the data exchanged by participants, but act as brokers or clearinghouses. Core federation services include participant identification, data exchange services and digital compliance. Application, service, and other providers participate and form a federated digital platform environment together with the core participants.

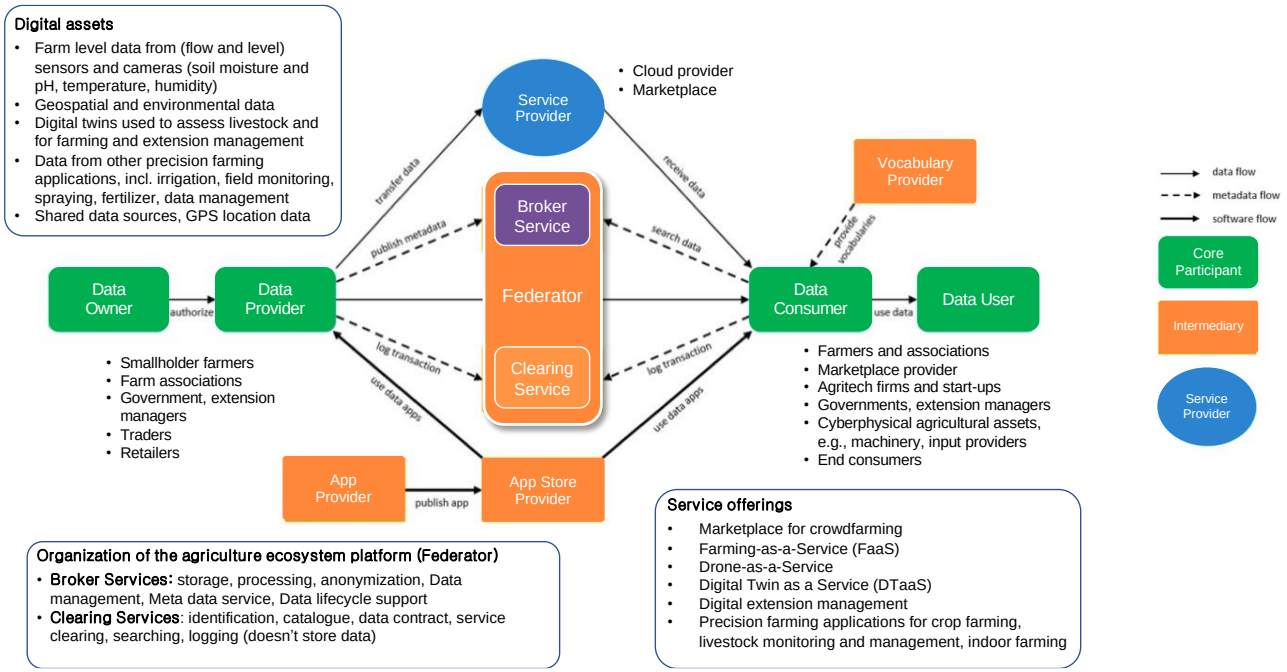

Figure 2: Digital assets, service offerings, and roles enabled by federated digital platforms

Note: Adopted and modified from IDSA Reference Architecture Model

Applying the federation concept shown in Figure 2 to the Botswana use-case, the role of data owners and providers are fulfilled by smallholder formers, farm associations, local governments, agricultural goods traders, and retailers that share their data securely within the trusted federated platform that is coordinated by the federator. Those data are transferred to cloud providers (e.g., IT-IQ, Nashua Nest, Data Cloud, or BTC Cloud Services), used for data aggregation and analysis, or are directly sent to digital applications that are offered by app and app store providers. Due to the potential value, data shared by the data providers are treated as digital assets, which could be farm-level data from (flow and level) sensors and cameras (capturing, e.g., soil moisture, pH, temperature, humidity data); geospatial and environmental data; digital twins are used to assess livestock and farming and extension management; other precision farming applications (e.g., for irrigation, field monitoring, spraying, fertilizer, and data management); and from GPS location data and other shared data sources (e.g., Google's Dynamic World offering near real-time 10m land use land cover datasets). The data providers are also data consumers or end users who themselves benefit from using data and benefits from the digital applications. In addition to the data providers mentioned above, data consumers and end users could also be digital marketplace providers, agritech and start-up firms, and end consumers. End-users are also cyberphysical agricultural assets like machinery and input providers. The core participants of such ecosystem, which mainly are the data providers and consumers, can benefit from emerging digital service offerings, including, crowdfarming marketplace, farming-as-a-service, drone-as-a-service, digital-twin-as-a-service, digital extension management, and precision farming applications. Finally, the federator is a trusted organisation within the technology and agriculture ecosystem ensuring the functioning of a digitally federated platform. It could be based on a consortium of stakeholders.

Federated digital platforms are realised in a flexible, agile, and bottom-up approach by focusing on scalable and marketable use cases that can eventually transform data sharing into shared data spaces, alliances, and more complex ecosystems. Digital federation or inclusive digital platforms, which enable sovereign data exchange, are particularly important for economies that lack big data. Sovereign data exchange means that data providers do not lose their data once they are sent to a cloud provider but remain the owner and can decide with whom to share the data. The concept of federation also means that data providers do not depend on a single vendor or cloud provider, which helps to bypass the limitations of the existing platform economy that lacked the concept of multi-cloud and multi-vendor approach. Thus, digital federation is indispensable for the emergence of a data-driven digital economy that depends on data aggregation and building larger datasets and algorithms.

More generally, Figure 3 highlights the evolution of digital platforms (Hagel 2015). Aggregation and social platforms were the first types of digital platforms that emerged and fundamentally

transformed the global economy. They have also led to data monopolisation and vendor dependencies. Traditionally, transferring data to other vendor's platform have been difficult and costly in the past, making customers dependent on a single cloud storage solution. In addition, those types of platforms have led to data monopolization creating a hierarchy between vendors and entire economies. Such concentration hampers inclusive digitalization and the tackling of broader issues that are of societal interest. Now, mobilization and learning platforms require a more open and inclusive architecture enabling longer-term and deeper relationships, and sharing of insights and data over time, which in turn can foster innovation. However, the main functions of aggregation and social platforms (like the facilitation of transactions and social interaction; connecting users to resources and users to communities; and mesh relationships network) will remain. Digital federation, as highlighted above, is a key technological enablement for mobilization and learning platforms.

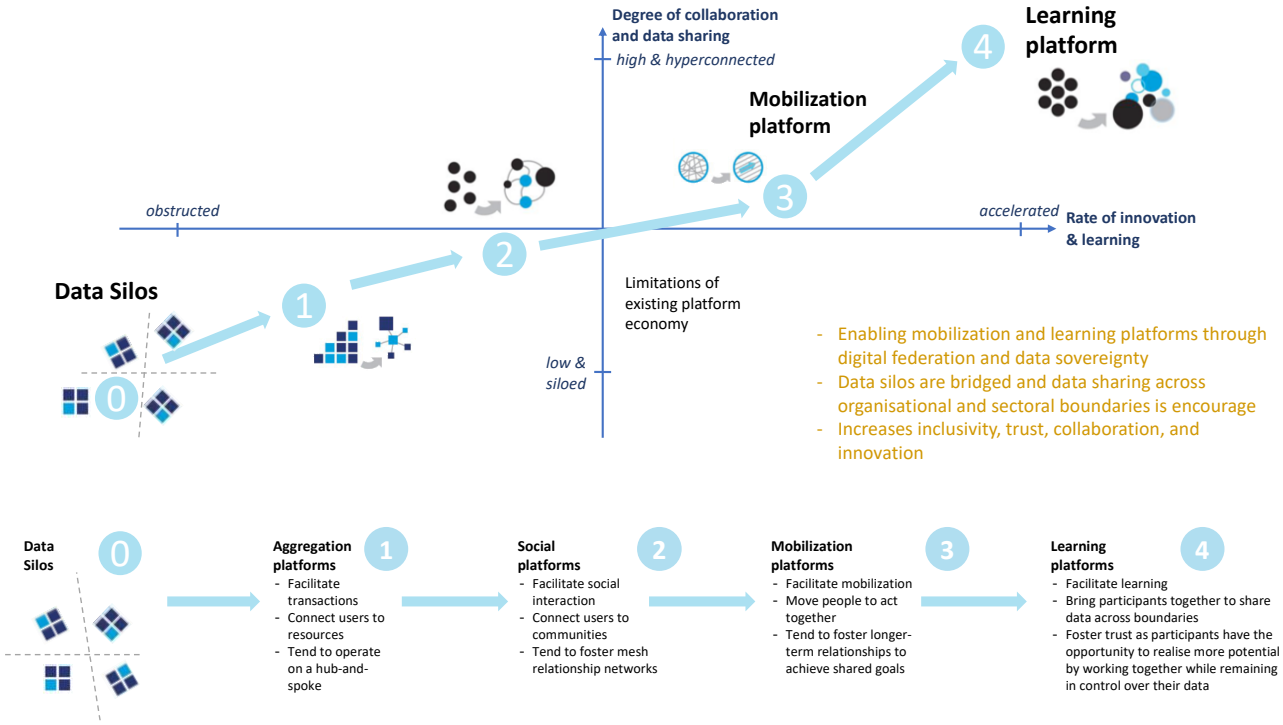

Figure 3: Leapfrogging from data silos and fragmented value chains to collaborative learning platforms based on digital federation
Note: Figure adopted from John Hagel 2015

Federation platforms could enable Africa to transform its emerging digital economies into mobilisation and learning platforms. They can help build data spaces and alliances within Botswana and with other African countries and the global digital economy. It can also help develop and scale advanced digital services that can strengthen Africa's COVID-19 reconstruction and preparedness and better respond to food security and inflation risks. The proposed approach builds on the digital alliance frameworks provided by the *International Data Spaces Association* (2021), the *European Union's Gaia-X programme* (2021), and the *United*

States National Institute of Standards and Technology (NIST) Cloud Federation Reference Architecture (Bohn et al. 2020; Lee et al. 2020; Kurz et al. 2011). Also, large private cloud providers or hyperscaler platforms like Google Cloud, Amazon AWS, and Microsoft Azure have started offering data sovereignty as ad-on services to address the demand for trusted, safe, and secure data sharing. For this project, the IDSA Reference Architecture Model was chosen as it is a comprehensive and practical framework and one that complies with the highest standards related to privacy protection and cybersecurity. It is also the basis for Gaia-X, which is Europe's flagship programme for promoting and implementing a federated digital infrastructure.

The need to build an inclusive digital economy is in line with *Botswana's Smart Botswana Strategy* (SmartBots), as highlighted above, as well as the *Africa Union's Digital Transformation Strategy for Africa* (Africa Union 2020) and *Smart Africa's Strategic Vision of Transforming the African Continent into Single Digital Market* (Smart Africa 2020). However, this research project was able to confirm that a direct implementation of a digital federation platform is not realistic or feasible given the lack of digitalisation in Botswana. Therefore, as described in the next section, this project created a digital transformation roadmap based on the principle of first providing a '*minimum viable service*'. As outlined below, the proposed roadmap consists of three development phases, which are interlinked as maturity levels of digital transformation and collaboration.

3 Digital Development Roadmap

3.1 From pilot project towards a digital ecosystem for inclusive smallholder agriculture

Given the high relevance of the primary sector in Botswana, this project focuses on the conditions and needs of smallholder agriculture in the country and the potential of its digital transformation. As mentioned earlier, smallholder farmers need to become more resilient and efficient to sustain their livelihoods and increasingly be able to compete in markets that are driven by commercial agriculture and vulnerable to external disruptions. Digital transformation plays a central role in increasing agricultural efficiency and resilience, but Botswana's smallholder sector has low digital transformation penetration and lacks the skills and capacity of digital implementation. This project will therefore explore digital federation as a technology that could help bridge the digital transformation gap and improve collaboration and innovation.

As described in section 2.3, digital federation is a general technological architecture enabled by recent advances in cloud computing and has emerged from the increased demand for

digital sovereignty, particularly in advanced data-driven economies. However, looking at this technology as a source of collaboration, efficiency and innovation has helped to identify a potential bridge between the specific conditions of Botswana's agricultural sector on the one hand, and the opportunities associated with trusted and inclusive data spaces on the other.

A key result of this project is the identification of a potential pilot project and a longer-term roadmap for transformation. The proposed roadmap consists of three development phases that are linked as maturity levels of digital transformation and collaboration. The pilot project, which focuses on smallholder agriculture in Botswana, defines the first phase of the roadmap, which will eventually lead to a marketplace and cloud-based ecosystem:

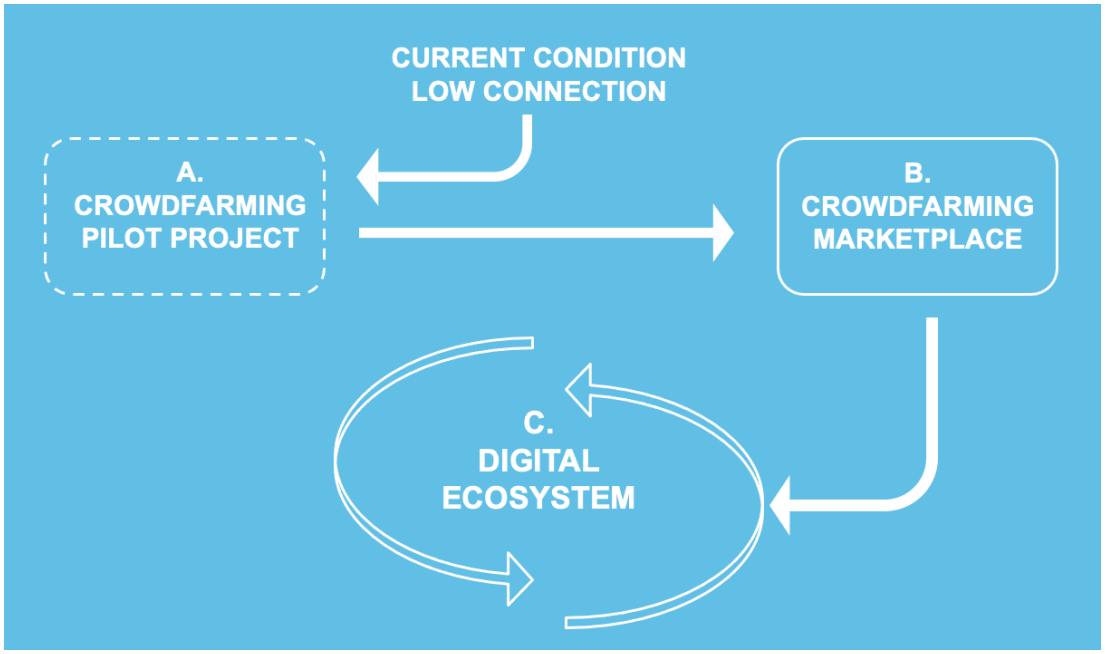

Figure 4: Roadmap towards a digital ecosystem for smallholder agricultural sector
Note: Authors' own illustration (2022)

3.1.1 A. Crowdfarming Pilot Project

The first phase of the roadmap, discussed in more detail below, is a start-up phase guided by the general idea of providing a "minimum viable service" (MSV), which focuses on minimum requirements of a service that has yet to prove the concept of delivering a larger digital transformation. Such an approach actively considers the low level of digital penetration of the primary sector in Botswana, while providing an incentive to connect smallholders (farmers and livestock producers) with consumers (including traders and retailers). Crowdfarming could be such minimal viable service. Crowdfarming is increasingly being used as an innovative, multi-local production model for agriculture, enabling smallholder farmers to better plan their harvests and increase yields while improving their financial security. Non-farming consumers are becoming virtual crowdfarmers, benefiting from the transparency of production and the origin

of products. They become remote farmers and investors. Crowdfarming can make the supply chain more efficient, reduce food waste and even mitigate the risk of inflation and supply chain disruptions. This phase is about providing proof of concept and specifying a sustainable business case. However, the MSV concept not only applies to the first phase, but also to the subsequent phases considering the low level of digital penetration throughout the entire roadmap.

3.1.2 B. Crowdfarming Marketplace

The second phase builds on the results and findings of the first phase and aims to develop the project into a marketplace or a tool into a product. While the first phase identifies and involves the initial participants of a crowdfarming production model and defines their roles, relationships, and transactions, which will be represented in a digital tool, the second phase establishes a suitable marketplace to attract and increase the number of crowdfarming participants. The marketplace will be based on an e-commerce shop and mobile applications with defined roles, ordering and fulfilment processes and financial transactions required to connect farmers with retail and wholesale customers. Accordingly, consumers can access the digital marketplace via a website or mobile application, select agricultural products and specify the quantity they wish to receive. The farmer himself executes the order as soon as the harvest season begins and delivers the goods to the consumer. The outcome of this phase is also the establishment of an organisation that operates and develops the digital marketplace based on a sustainable income model.

3.1.3 C. Digital Ecosystem for Smallholder Agriculture

In the third phase, the crowdfarming marketplace will then be developed into a trusted digital platform for sharing data and applications and other digital assets. It involves the pooling of farmers and stakeholders providing and sharing those digital assets. This platform will be based on a federated architecture, as described in section 1.3. This phase will therefore expand the focus from agricultural production and marketing to a data and technology-driven approach to agriculture or precision agriculture. Precision agriculture includes digital technologies such as mobile phones, remote sensing (satellites), drones, the Internet of Things (IoT) and its sensors, cloud computing, low-power wide area network (LPWAN) and artificial intelligence (AI). These technologies are increasingly being used in agriculture to improve productivity and yields (UNDP 2021). Based on the priorities derived from the expert interviews and focus group, precision agriculture will focus on cropping, livestock, and extension management. The collaborative aspect of such a federated ecosystem is that smallholder farmers can afford these advanced technologies as they are provided an as-a-service business model

(e.g., drones as a service) to serve a large number of farmers through farmer groups or co-operatives. Such collaborative connectivity can also encourage the adoption of new service models, including supply/cold chain as a service. The data generated by these groups can be aggregated and reused to develop new digital services that are made available to the ecosystem. This turns the platform into an innovation ecosystem or learning platform, bringing in new participants such as technology start-ups and other small and medium-sized enterprises. However, each group would retain ownership of its data and digital assets, which is a key design principle of digital federation and data sovereignty. Such a platform could not only increase the efficiency and resilience of agriculture, but also create new jobs. Based on the emerging ecosystem platform, the crowdfarming marketplace from Phase 2 will be further developed into a Farming as a Service (FaaS) model, which would allow stakeholders to set up their own crowdfarming marketplaces that connect farmers and consumers in an affordable and efficient way. A network of farming hubs, managed through digital systems and agricultural professionals, will be equipped with basic and precise farming practices throughout the production cycle of crop and/or livestock production.

Overall, the successful implementation of the Roadmap depends on the successful activation and engagement of participants at each stage: Tool, Marketplace and Ecosystem. A key premise of the project is the use of existing open-source technologies, an e-commerce shop and a cloud computing environment that can be adapted to implement each phase of the Roadmap. Local service providers will be involved. The project follows an agile project management approach that flexibly follows the principles for building a technology platform for digital enterprises. Another important design rule, as described above, is the concept of digital federation, which ensures openness, interoperability, inclusivity and data sovereignty. The aim is not to monopolise crowd and precision farming, but to build a trusted ecosystem that will primarily help mobilise Botswana's smallholder farmers, lower the barrier to digital transformation and create an environment for collaboration and innovation.

3.2 Development roadmap first phase: A. Crowdfarming Pilot Project

The starting point of the proposed development plan is a pilot project with the aim of developing a minimum viable digital marketplace for crowdfarming that connects selected farmers with consumers in Botswana. Proposing the pilot project as part of the roadmap is the main outcome of this ITU Connect2Recover research study. The following phases are proposed that would lead to an operational launch of a crowdfarming marketplace, production, and consumption model.

Table 4: The three phases of launching the crowdfarming marketplace

Stage	Sub-stage	Tasks	Botswana context
1. Analysis and stakeholder selection	Market analysis	Market definition, direction and analysis, incl. analysis of marketplace technologies, participants, agriculture production and farming operations and regions	Main consumption: Gaborone Production: Pandamatenga, Tuli Block, Babirwa regions
	Technology selection	Selection of a service provider and marketplace development technology	e.g., BoFiNet, BTC, Mascom, Orange
	Stakeholder selection	Selection of pilot farmers, traders, retailers, and consumers	Bushra Farm, Phalanyana Farm, Square Mart, Choppies or others selected
	Ideation Workshop	Requirement gathering workshop with farmers, farm association, traders, extension managers	SmartBots and government involvement
2. Design and implementation	Marketplace design and configuration	Designing and customizing digital marketplace and logistical, payment, customer service processes (front-end, backend, mobile app) for farmer-to-business and farmer-to- consumer business models	Together with selected service provider
	Remote farming operations design	Planning for digitally enabled remote livestock production and farming, selecting agricultural goods for crowdfarming	Bushra Farm, Phalanyana Farm or others selected
	Marketplace organization	Setting up organization running the marketplace and coordinating network of remote farms	e.g., public-private partnership
	Establish Finance facility	Set-up micro-financing mechanism for smallholders to bridge financing gaps	e.g., Letshego, CEDA, LEA
3. Launch and operations	Launch of pilot operations	Launch of pilot operations with confirmed participants for one harvesting season and live-stock production and sales cycle	
	Scaling-up	Marketing, product management, acquisition of new marketplace participants, extending regions	
	Improvement projects	Good agricultural practices, access to quality inputs, rehabilitation and replanting of crops, digital extension management	
	Preparing for next roadmap phase	Conceptualization fully operational crowdfarming marketplace, farming as a Service business model, and platform for precision farming	

Considering the limitations of the digital transformation in agriculture (e.g. low internet access, connectivity issues, lack of farmers' digital skills, interoperability of systems, benefit-cost ratio and lack of willingness to share data), the research team proposes to conduct a SWOT (strengths, weaknesses, opportunities and threats) analysis with the selected stakeholders during the initial phase to further analyse potential risks and opportunities and identify appropriate mitigation measures.

4 Conclusion and Recommendation

Supporting the broader objectives of the ITU Connect2Recover initiative and Africa's digital transformation strategy, this project set out to identify potential industries, stakeholders, and use cases for the development of a federated digital platform and advanced services with a focus on Botswana. Based on extensive secondary and empirical research, the project team identified and outlined the major challenges and opportunities of Botswana's stage of digital maturity or readiness and the general prospects of digital federation and a shared data economy. Botswana's smallholder agricultural sector has been identified as the most important area of digital transformation given the importance and the development need of the country's primary sector. The project team has been successful in receiving commitment from actual smallholder farmers, farmer association and government supporting the idea of developing a crowdfarming marketplace and, eventually, an agriculture ecosystem for smallholder farmers, livestock producers, and agricultural technology companies and start-ups. An inclusive, farmer centric crowdfarming production model with an integrated payment system/e-commerce would help increase overall resilience, financial capacity, and production efficiency due to better market accessibility, direct funding, and technology sharing collaboration opportunities. Crowdfarming is seen as a promising way to increase digital connectivity for remote farmers to relevant agribusiness stakeholders and markets. Thus, this report is primarily a proposal for such follow-on pilot project to develop a minimum viable digital marketplace for crowdfarming that connects selected farmers with consumers in Botswana and thus, this pilot project provides a funding opportunity for potential partners and donors.

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6 Appendix

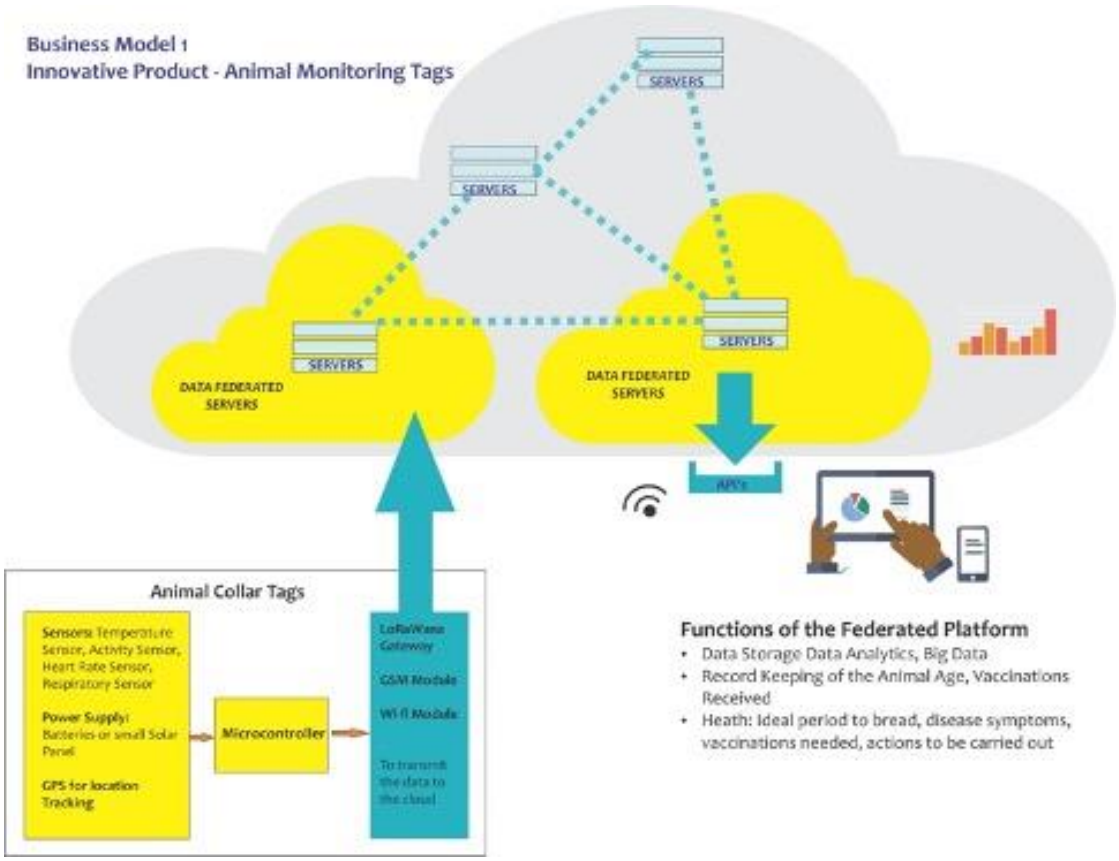
6.1 Where do the Stories Meet: Federated Platform for Small Stock Farming in Botswana

Small digital players can start collecting data and leaving a digital footprint by using federated platforms to improve their overall linking capacities, knowledge sharing and information acquisition to better flourish and become more resilient towards short- and medium-term shocks as well as cascading and systemic risks (UNDRR and UNU-EHS 2022 a, b).

The co-creative project process identified two possible use cases that have been discussed with a broad and diverse group of stakeholders working in or being linked to the small livestock farming sector in Botswana. The suggested opportunities have both the potential for further scalability towards other user groups in different sectors. However, the current technological development, equipment and readiness of the small-scale farming sector led to the decision to elaborate and push for the most promising opportunity – see section 2: Development roadmap – From digital tool over marketplace to federated ecosystem for smallholder agriculture – suggesting a low-profile access including stages of maturity towards an active federated platform model.

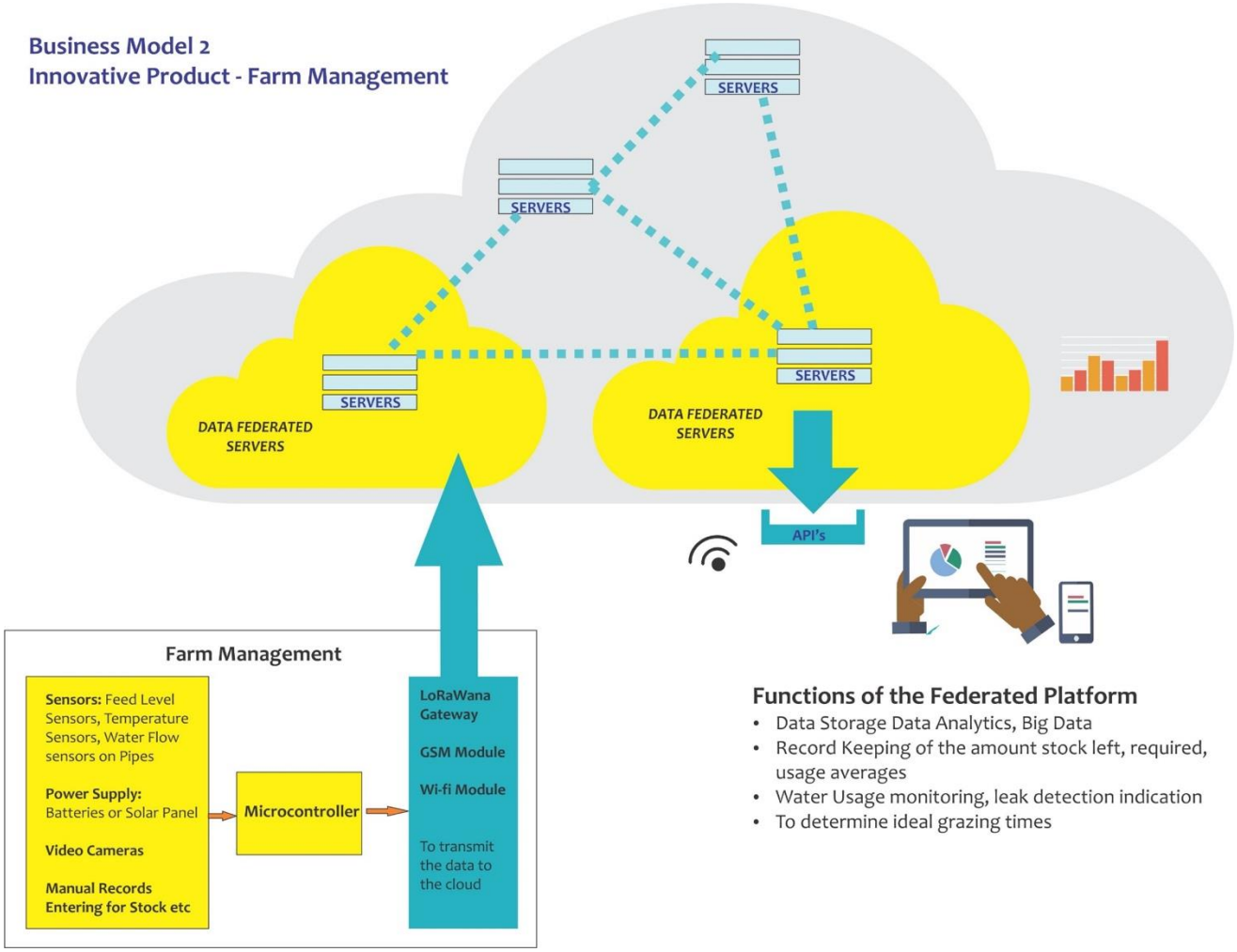
In the following the other two discussed opportunities are illustrated:

Opportunity 1: Federated Platform for Animal Monitoring



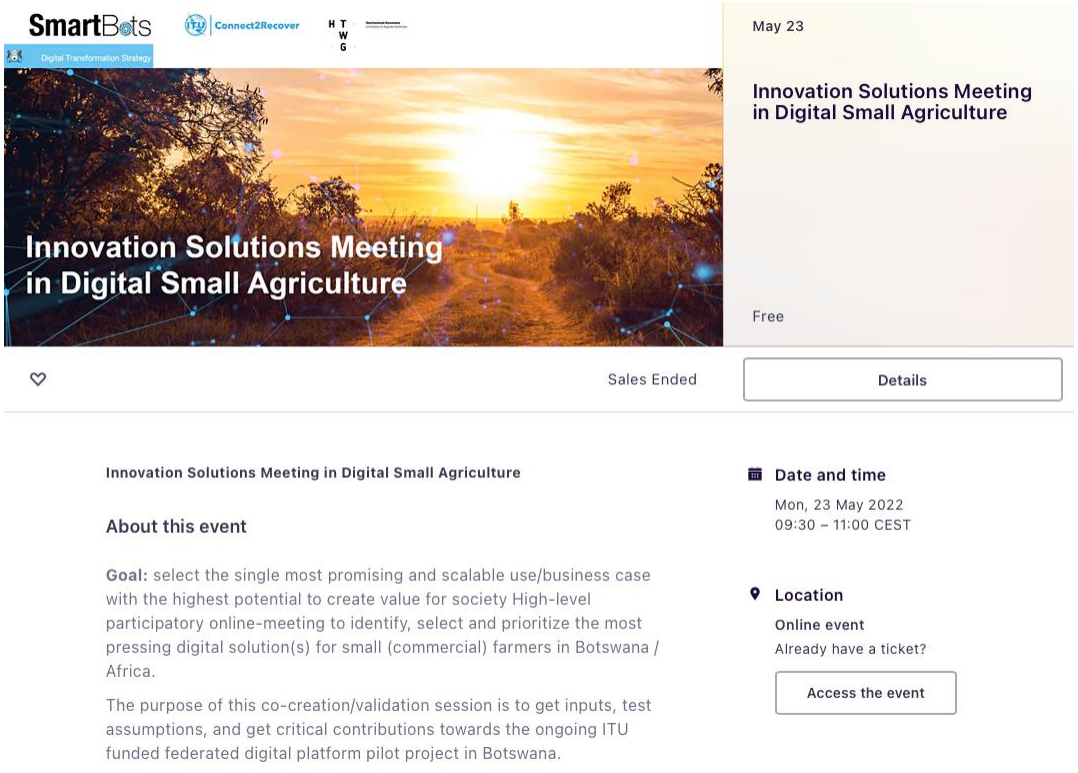
Source: Sajid Sheikh 2022

Opportunity 2: Federated Platform for Farm Management



Source: Sajid Sheikh 2022

6.2 Innovation Solutions Meeting in Digital Small Agriculture



Participants:

13 from relevant stakeholders (smallholder farmers, academia, farmer association) from Botswana

Output:

- Deepen understanding of smallholder farming situation, challenges, obstacles, challenges but also solution-oriented innovations
- Strengthen development roadmap for building digital tool and marketplace for crowd-farming

Outlook for implementation and next steps

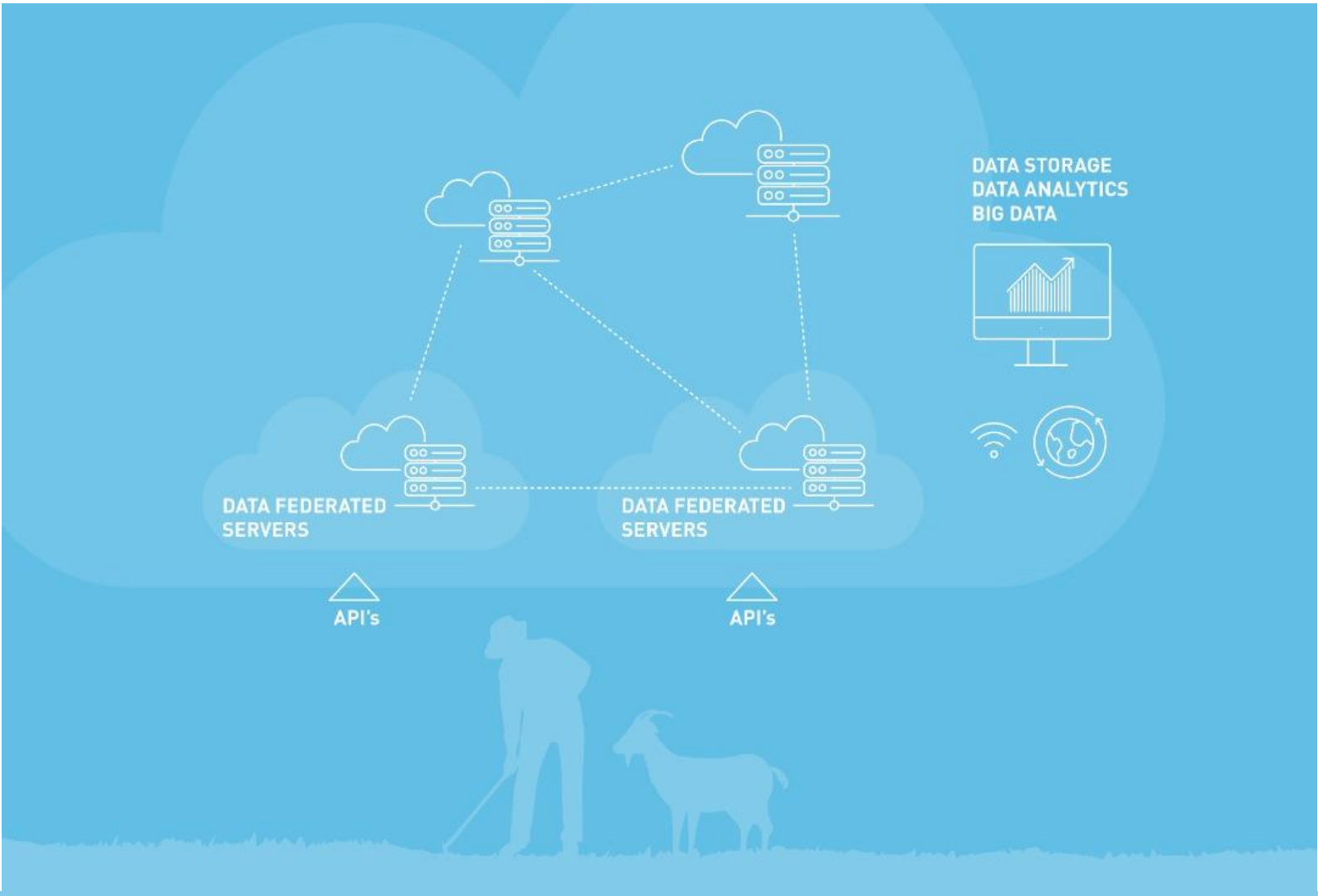
6.3 Pre-selected Interview Questions and Guideline

GUIDING QUESTIONS – SMALL STOCK FARMERS

Name of Person	
Name of Farm	
Farm owner or which relation to farm	
Location of interview	
Date of Interview	

QUESTIONS

Small Stock Famer		Comments
1	What are your farming activities?	
	IF ANIMALS: How many small stock animals do you have? And types? IF HORTICULTURE: How large is your horticulture?	
	What is the size of your farm?	
2	What are the challenges you face	
	Electricity	
	Water	
	Internet Access	
	Mobile Phone Coverage	
	Animal Tracking	
	Theft of animals	
	Labour and costs	
	Animal Disease and Outbreak	
	Weather Conditions / Climate Change	
	Others	
3	How has technology helped you improve your services or how you carry out your activities?	
4	Do you use technology for any of the below	
	Animal Tracking	
	Electronic ear tags	
	Electronic weighing	
	Camara monitoring	
	Milk temperature sensors	
	Automatic feeding systems	
	Disease detection	
	Others	
5	How do you think technology can help you improve / automate your farming activities? Did you hear about technologies that support farming? Do you have ideas, visions of how and which technology can support your farming activities?	
6	How do you market your products?	
7	How do you monitor the health of the animals / farm products?	
8	Can you supply us photos of your farm?	
Small Stock (goat) Farmers Association		Comments
1	What are ideas to support small stock farmers regarding technology?	
2	Where do you see potentials for technical advance and support?	
3	Do you have visions / ideas how to use technology supporting small stock farmers?	
4	Do you know about digital platforms? Do you use them for supporting small stock farmers? Or other(s)?	
5	What are the biggest challenges for small stock farmers?	
6	How do you as an association support these challenges to make small stock farmers more resilient?	



Project Team

- Prof. Dr. Michael Max Bühler, University of Applied Sciences Konstanz (HTWG), Germany
- Dr. Thorsten Jelinek, Senior Fellow, Taihe Institute, China
- Prof. Dr. Konrad Nübel, Technical University of Munich, Germany
- Vasilis Koulolias, Executive Director and Founder, eGovlab, University of Stockholm, Sweden
- Loungo Monchusi, Development Cooperation Lead at SmartBots, Government of Botswana
- Ron Bakker, Founding Partner, PLP Architect, London, United Kingdom

Research Team

- Dr. Pia Hollenbach, Senior Researcher, Institute of Geography and Sustainability, University of Lausanne, Switzerland
- Yame Nkgowe, Founder, Sustainable Cities Africa, Botswana
- Dr. Sajid M. Sheikh, Senior Lecturer, Electrical Engineering, University of Botswana