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Sustainable business models for smallholder farmers: Challenges for and lessons from the Barsha pump experience

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Abstract

Smallholder farmers (SFs) are cornerstone actors in eradicating poverty and hunger. Companies have recently focused on SFs as potential customers and suppliers. Several hindrances yet prevent SFs to be commercially viable actors. In this respect, sustainable business models (SBMs) bring opportunities for companies to increase profit, improve SFs' livelihoods, and promote environmental sustainability. Recognizing these opportunities, the Dutch company aQysta provides the Barsha pump (BP) as a sustainable irrigation solution for SFs. The challenges for BP adoption that remain for SFs illustrate that there is still limited understanding of how SBMs can support companies in engaging with SFs. To expand this understanding, we conducted a multiple-case analysis of 10 organizations providing SF-tailored products and/or services. Based on this analysis, we have drawn lessons for aQysta (and similar companies) to improve the BP's value proposition and we elaborate on the implications of this study for other organizations engaging commercially with SFs.

KEYWORDS

Barsha pump, hydro-powered pump, irrigation, product-service systems, smallholder farming, sustainable business models

1 | INTRODUCTION

Eradicating poverty and hunger are main priorities on the global development agenda (Sustainable Development Goals [SDGs] 1: No Poverty, and 2: Zero Hunger). In the next three decades, about 685 million people must move above the deep poverty line (The World Bank, 2022), and global food production must increase by with about 50% (FAO, 2017). Smallholder farmers (SFs), comprising 70% of the global poor (Giordano et al., 2019), are key yet usually neglected actors in coping with these two challenges (Gomez y Paloma et al., 2020; Nwanze & Fan, 2016). First, interventions in the SF sector are up to eleven times more effective in poverty alleviation than in other fields (Giordano et al., 2019). Second, SFs are responsible for a significant global production of staple crops (e.g., 64% of rice, 50% of groundnut, 23% of wheat) (Giordano et al., 2019; Gomez y Paloma et al., 2020). In addition, SFs can contribute to other development areas: gender equality (SDG 5), decent and inclusive work (SDG 8), and protection of biodiversity (SDG 15) (Giordano et al., 2019; Gomez y Paloma et al., 2020; Poole, 2017; Terlau et al., 2019).

In recent years, private companies have seen in SFs a source of untapped opportunities for their businesses (TechnoServe, 2021). SFs are both a source of produce for agri-processors, and an attractive market for providers of products and services (Franz et al., 2014; TechnoServe, 2021). Adequate business strategies have thus the potential to generate both social impact for underserved SFs and revenues for companies. However, several hindrances prevent SFs from becoming commercially viable partners in the agrifood value chains. A prevalent challenge is SFs' limited access to products (e.g., farming inputs, machinery and other technologies) and services

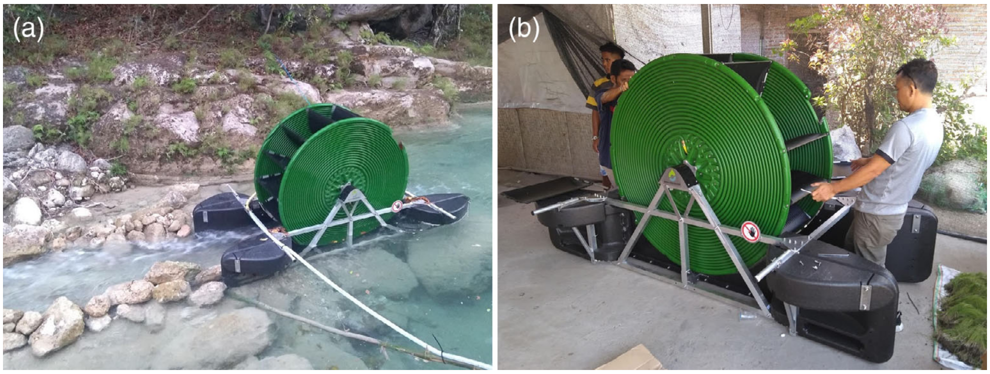

FIGURE 1 The Barsha pump. (a) Installed and operating in a river. (b) Being assembled before its installation.

(e.g., extension, finance, mechanization, market linkages) required to be more productive (Gomez y Paloma et al., 2020). Other challenges affecting SFs are the vulnerability to climate change (particularly in rainfed systems), land insecurity, limited access to irrigation and energy, inadequate regulatory environment, informal markets, and volatility of prices (Giordano et al., 2019; Gomez y Paloma et al., 2020).

Through properly designed business models (BMs), companies can improve their commercial engagements with SFs (Geissdoerfer et al., 2018; Groot et al., 2019; IDH, 2019; Long et al., 2017; TechnoServe, 2021). Furthermore, by innovating towards sustainable BMs (SBMs), these companies have not only the potential to bolster their long-term profitability, but also to include SFs in the agrifood value chains (and create higher value for their communities) while promoting environmental and social sustainability (Michelson, 2020; Schoneveld, 2020; Sulle et al., 2014; TechnoServe, 2021; Vorley et al., 2009). To reach that potential, companies typically require support in deploying a fully-fledged SBM structure (Adjogatse & Saab, 2022). That support demands the coordinated interaction of public and private actors (e.g., governments, financial institutions, retailers, and research institutes) in an adequate business ecosystem (Adjogatse & Saab, 2022; TechnoServe, 2021). By implementing SBM strategies, companies can ensure the effective provision of their products and services, and stimulate continuous participation of SFs in better markets (TechnoServe, 2021).

Recognizing these pressing issues, the Dutch company aQysta developed a BM focused on irrigation solutions for SFs. Investing in irrigation is a key intervention to improve SFs' productivity and livelihoods (Giordano et al., 2019). With secured irrigation, SFs create opportunities to farm year-round, diversify crop production, improve yields and quality, increase profits, and respond to erratic rainfall patterns (Izzi et al., 2021). In this context, aQysta has developed the Barsha pump (BP), designed to cater to SF's irrigation needs. The BP is a hydro-powered device that builds pressure through two spiral pipes driven by a waterwheel. It is installed in rivers or canals (Figure 1a) with a flow rate of at least 300 $L\ s^{-1}$ and a water velocity of about 1 $m\ s^{-1}$. It has a diameter of about 1.5 m (Figure 1b) and weighs around 90 kg. In ideal conditions, the BP pumps a maximum of 20–80 $m^3\ d^{-1}$ (0.23–0.93 $L\ s^{-1}$) up to 20 m head (or 1 km in horizontal distance).[1] According to aQysta (2018a), the BP can irrigate up to 2 ha. The BP is currently used in several countries, with its principal markets being Nepal, Indonesia, Malawi and India (aQysta, 2018b). For a comprehensive description of the BP and its context of use, please refer to Intriago Zambrano et al. (2019) and Intriago Zambrano et al. (2022).

aQysta claims that the BP is a better solution for SFs than diesel-powered irrigation (aQysta, 2019). The BP is said to be more affordable and cost-effective for SFs. The BP bears virtually zero operation costs by not operating on fossil fuels. The BP allegedly creates more impact among SFs, especially the most disadvantaged ones. By not relying on fuels' supply chains or electricity networks, the BP delivers higher value in remote, off-the-grid, and probably more marginalized agricultural areas. The BP is claimed to bear a simple and robust design that facilitates its operation and maintenance. By using only mechanical parts, and not electric or electronic components, its maintenance is limited to cleaning the waterwheel, (re)adequate the installation site, and repair/replace any damaged part. Lastly, the BP is said to be a more environmentally sound technology. By not emitting combustion gases, and not relying on fossil fuels, irrigating with the BP poses a negligible environmental footprint.

Notwithstanding aQysta's claims, and despite the BP's advantages, its adoption[2] among SFs remains challenging. According to some authors (Ali et al., 2016; Bastakoti et al., 2020; Intriago Zambrano et al., 2019; Kiprono & Ibáñez Llario, 2020; Kumar et al., 2020), multiple barriers prevent SFs to adopt these technologies, and thus to unlock SFs' potential through controlled irrigation. Among these are high upfront costs and associated cumbersome access to capital, site-specific limitations, unavailability in local markets, absence of local expertise, limited access to information, and poor training and capacity building.

[1]Maximum pumping specifications are traded-off, that is, it is not possible to meet them all simultaneously.

[2]We acknowledge the shortcomings of the 'technology adoption' concept. This term, as Glover et al. (2019, p. 169) state, "simplifies and mischaracterises what happens during processes of technological change", a claim even more relevant when considering other aspects such as sustained/continued adoption over time (Theis et al., 2018). As our focus in this text is not on the adoption concept, however, we do use the term 'adoption' as 'the decision of an SF to make use of certain product/service'.

This paper aims to connect aQysta's BP-related experience to other studies on these limitations within SF contexts. Several researchers have studied BM frameworks to deliver value more effectively to SFs (CGIAR, 2017), the creation of business cases for SFs through BM innovation (Bolwig et al., 2020; Gebrezgabher et al., 2021; Otoo et al., 2018), and the SBM structures of companies engaging commercially with SFs (Doherty & Kittipanya-Ngam, 2021). These results are extremely valuable, but specific knowledge on the relationship between companies' SBM strategies and the value they deliver to SFs remains rather limited. To further understand how companies' SBM strategies can deliver higher value to SFs, while generating profit and promoting environmental protection, we present a qualitative multiple-case analysis of 10 SBM cases. Our study aims to: (1) understand how companies contribute to SFs' development by delivering higher value through SBM strategies, and (2) draw lessons on SBM innovations for companies that engage with SFs, using aQysta/BP as an example.

The structure of this paper is as follows. Section 2 describes the multiple-case study research method, the sampling techniques and case selection criteria, and the data collection and analysis methods. Section 3 presents the synopsis and description of the selected case studies. In section 4, we elaborate and discuss the thematic patterns of SBM strategies. Both the synopses and the thematic strategies are of interest to non-profit organizations (NGOs), practitioners, and policymakers focused on SBM innovations. Section 5 discusses lessons for aQysta's BP and its value proposition. In section 6, we elaborate on the implications of these findings for similar providers of products/services aiming to SFs as customer segments. Lastly, we present our conclusions in section 7.

2 | METHODOLOGY

2.1 | Research method: Multiple-case study

The study of SBMs to deliver value for SFs, as an incipient research domain, presents three key characteristics mentioned by Yin (2018). First, it aligns with the need of answering the 'how' between SBMs and delivery of value to SFs. Second, it provides the researchers no (or quite little) control over these societal events (both at SBM and SF level). Third, it is not a historical but rather a contemporary phenomenon, whose theory has not been comprehensively built.

Based on those three characteristics, we opted for the case study research method to explore the relationship between SBMs and the value delivery to SFs. Moreover, we decided to undertake a multiple-case research design to: (1) increase the reliability and robustness of the study; (2) allow independent analytic conclusions to emerge from each case, through within-case analyses; and (3) deliberately select contrasting situations across cases, through cross-case analyses (Eisenhardt, 1989; Yin, 2018). Through the within-case analyses, we generate case-based theoretical notions from the SBM strategies of each firm/organization. In the cross-case analysis, we look at evidence through multiple lenses to identify thematic areas of interventions for businesses to innovate towards SBMs.

2.2 | Case study structure: Sustainable business model canvas

BM definitions are subject of debates among researchers (Bocken et al., 2014; DaSilva & Trkman, 2014). For practical reasons, in this research we resort to a value-centered definition: a BM is a strategic blueprint that "describes the rationale of how an organization creates, delivers, and captures value" (Osterwalder & Pigneur, 2010, p. 14). In recent years, and strongly driven by the global development agenda, this definition has shifted towards inclusive growth and environmental sustainability. This change challenges the traditional income-oriented growth discourse by incorporating social and environmental justice principles (Schoneveld, 2020). In this regard, SBMs have emerged as dynamic instruments with a strong potential of creating synergies between the well-being to communities, environmental benefits, and economic profit to firms (Dembek et al., 2018; Evans et al., 2017). In this research, therefore, we structure the selected case studies according to the SBM canvas, its four overarching value-categories, and its 11 building blocks, as proposed by Bocken et al. (2018). This structure can be seen in Figure 2.

2.3 | Selection of case studies

2.3.1 | Sampling techniques

We selected 10 case studies through purposive and convenience sampling techniques, based on two approaches: (1) maximum variation sampling, which "aims at capturing and describing the central themes that cut across a great deal of variation" (Patton, 2015, p. 428), and (2) the theoretical (i.e., not random) sampling principle, which "(f)ocuses efforts on theoretically useful cases—that is, those that replicate or extend theory by filling conceptual categories" (Eisenhardt, 1989, p. 533). We opted for the combination of these approaches to enrich the theory of SBM strategies to deliver value to SFs. In addition, we aim to inform specific audiences (i.e., policymakers, NGOs, companies, and practitioners) about the spectrum of opportunities within this field of knowledge.

2.3.2 | Selection criteria

For our study, the selected cases must comply with three criteria:

- A possible maximum degree of variation across SBM structures (i.e., product-oriented to service-oriented), geographies (i.e., continents and countries), involved actors (e.g., public, private, NGO, civil society) and size of organization/SBM structure. This variation allowed us to identify themes and patterns of SBM strategies across the heterogeneity of cases.

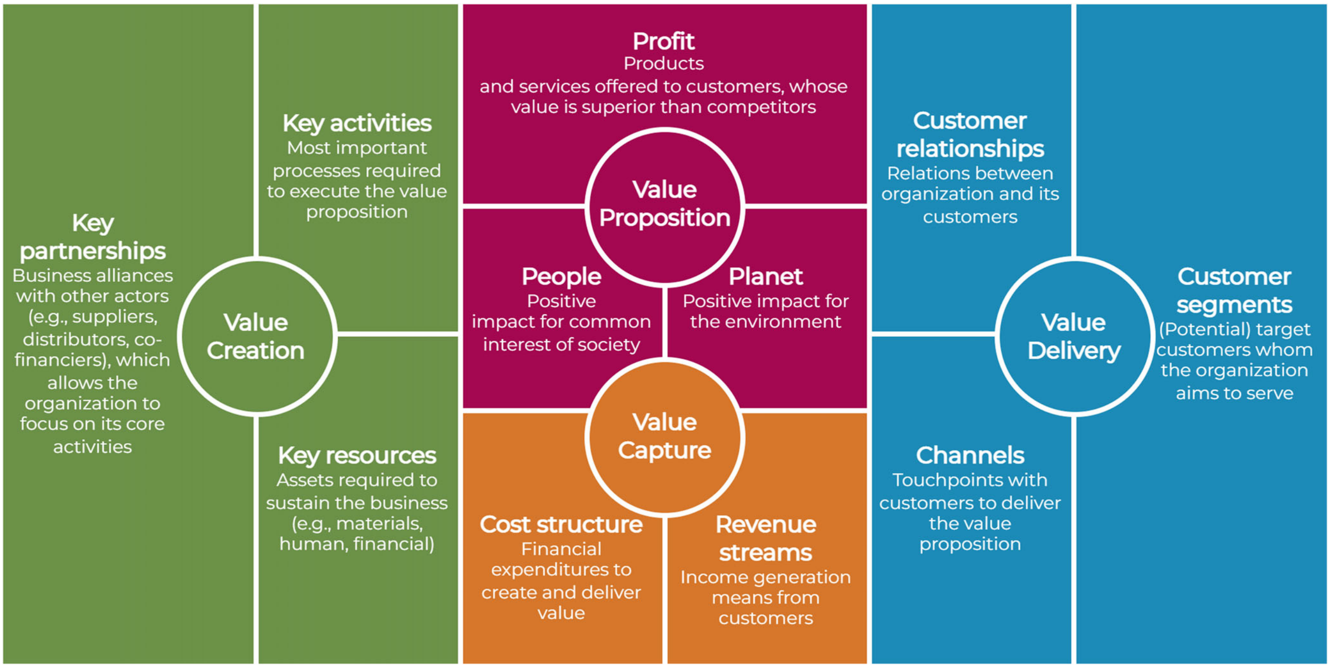

FIGURE 2 Structure of the sustainable model canvas (adapted from Bocken et al., 2018).

- The (main) customer segments are SFs located in the Global South.[3]
- To enrich the analysis of business strategies, the SBMs' value propositions pose an innovation in their structures beyond the traditional selling-buying model (i.e., upfront purchase).

2.4 | Data collection

The dataset of the 10 case studies comprised both primary and secondary data. Primary data, collected between June 2019 and August 2021, consisted mainly of online semi-structured interviews. Our interview guide follows the eleven building blocks of the SBMs canvas (as proposed by Bocken et al., 2018), can be found in the Appendix A of Supplementary Materials (Intriago Zambrano, 2022). In addition, the aQysta-related cases included field observations and extensive face-to-face discussions as well. We interviewed key actors in different case studies, such as CEOs, managers, experts, and representatives of the organizations involved in the SBM structures. The interviews usually lasted 60 min and were recorded and transcribed upon prior agreement of the interviewees. All the case studies were complemented by secondary data, which consisted of (non)scientific articles and reports, marketing material and corporate online information.

[3]The Global South–North divide has been criticized as a controversial concept (Sajed, 2020), similarly to other ones like 'developing-developed countries', 'majority-minority world', or 'third world countries'. Given that many leading scholars in development studies advocate the Global South–North dichotomy (Berger, 2021; Clarke, 2018; Dirlik, 2007), we did opt for the term. Moreover, we do not elaborate on its drawbacks since epistemological discussions on the concept are out of the scope of the present work.

2.5 | Within-case analysis

We conducted the within-case data analysis using "detailed case study write-ups for each (case). These write-ups are often simply pure descriptions, but they are central to the generation of insight" (Eisenhardt, 1989, p. 540). Each write-up focused on understanding the SBM strategies within a single case and its respective products/services delivered to SFs. These individual analyses provide a synopsis of how the respective organizations create, deliver and capture value regarding their SF customer segment.

2.6 | Cross-case analysis

From the three tactics for cross-case analyses described by Eisenhardt (1989), we chose "to select categories or dimensions, and then to look for within-group similarities coupled with intergroup differences" (Eisenhardt, 1989, p. 540). We focused on five consecutive dimensions/themes,[4] which range from the SF's access to certain product/service, to the profit that the SF makes based on the use of that product/service. The dimensions of this 'access-to-profit' cycle, and their clustered SBM strategies, are as follows:

1. *Information and knowledge*: strategies to make SFs aware and informed about available products/services.
2. *Capital and financial services*: strategies to make products/services affordable for SFs.

[4]Given the lack of standardized themes in the extant literature, we chose the five dimensions based on the clusters that emerged from the collected data, as suggested by Eisenhardt (1989).

3. *Training and capacity building*: strategies to empower SFs on how to use products/services effectively.
4. *Rural logistics and supply chains*: strategies to ensure that products/services are delivered to SFs over time (e.g., inputs, spare parts, servicing, etc.).
5. *Connection to markets*: strategies to ensure SFs make profit based on using the products/services.

The cross-case analysis is particularly relevant to build theory on how SBMs stimulate the SF adoption of products/services, while generating profits, and promoting environmental protection. This analysis allowed us—through the use of structured lenses (Eisenhardt, 1989)—to identify common patterns emerging from the diversity (Patton, 2015) of SBM strategies.

2.7 | Lessons-drawing

To draw lessons, we resorted to a framework adapted from Rose (2002, 1991). First, the results of both within-case and cross-case analyses were the source for SBM strategies. Second, based on that empirical evidence, we formulated SBM innovations that companies can implement. This formulation followed the 'synthesis' lesson-drawing (Rose, 1991), whereby the proposal combines recognizable elements from different SBM structures into a distinctive whole. Third, we discuss the gains the proposed interventions may bring to aQysta/BP.

3 | SYNOPSES OF CASES

Based on the selection criteria, we chose cases of 10 organizations, with offices in several countries, offering a range of agricultural products/services to SFs. Table 1 shows an overview of the cases, specifying the organization's name, type of product/service offered, locations of both provider organization and SF target customers, (types of) actors involved, and details of collected primary and secondary data.

In consonance with the theoretical and maximum variation sampling approaches, we selected the cases to ensure SBM diversity across categories. These categories covered the complexity of the network of actors (and its capacity to co-create value); provision of products/services or bundles; types of actors (see also column 4 of Table 1); and, relative size of leading organizations. In addition, by mapping these categories across network size and provision of product/service (Figure 3), we can cluster the cases in:

a. Single actor – product: aQysta (Nepal), Futurepump
b. Single actor – product/service bundle: aQysta (Indonesia), Sesi Technologies
c. Single actor – service: ADBL
d. Tandem of actors – product: MORINGA
e. Tandem of actors – product/service bundle: (B)energy, Organization X
f. Tandem of actors – service: Dimitra, MetKasekor

Table 2 shows the SBM structures of the selected cases. These structures reflect how each organization contributes to development by proposing, creating, delivering, and capturing value in its engagement with SFs. These value dimensions encompass the SBM building blocks (Bocken et al., 2018). To align with those building blocks, we split the value proposition into people, planet, and profit.

To increase our understanding of the 10 cases, we elaborate on the description and SBM innovations of each case. The innovations can be of different nature, for example technological (hydro-powered pumping, digital platform), financial (tailored microcredits, flexible payment schemes), logistical (multi-tier distribution), or strategic (key partnerships, product/service bundles). The description of the cases can be found in Appendix B of Supplementary Materials (Intriago Zambrano, 2022).

4 | A CROSS-CASE ANALYSIS OF BUSINESS STRATEGIES

The case analyses offers the basis for the cross-case analysis, emphasizing similarities and differences between cases (Eisenhardt, 1989; Yin, 2018). We conducted the cross-case analysis across the five proposed dimensions of the 'access-to-profit' cycle, namely: (1) information and knowledge, (2) capital and financial services, (3) training and capacity building, (4) rural logistics and supply chains, and (5) connection to markets.

4.1 | Information and knowledge

Access to information is a key resource for SFs. Availability of relevant, accurate and timely knowledge is an enabler to make informed decisions. With that information, SFs can decide whether to use certain machinery or input, or where and how to request a microcredit (Ndimbwa et al., 2021; Poole, 2017). However, proper access to information and advisory services remains challenging for most SFs worldwide (FAO, 2020). According to the FAO (2020), there is a substantial disconnection between SFs and information suppliers (i.e., governments, companies, researchers). Suppliers tend to generate potentially irrelevant information that sometimes is inaccessible to SFs. In addition, SFs are rarely involved in the co-creation of that knowledge.

Some of our cases rely on traditional information channels, including direct branding and advertisement through local branches. This strategy is prevailing in the BP in Nepal, Futurepump through its national distributors, and the ADBL. For this strategy to be effective, the brand/product must be linked to a long-standing actor that SFs can recognize more easily. Futurepump leverages on the prestige and leading presence of Davis & Shirtliff in East Africa (Davis & Shirtliff, 2022). ADBL builds on its background as a predominant stakeholder in the agrarian history of the country (ADB/Nepal, 1982; Banskota, 1985). Direct advertising does not guarantee outreach and

TABLE 1 Selected case studies and details of collected data.

Case[a]	Locations: Organization	Locations: SFs	Actors involved	Collected data: Primary[b]	Collected data: Secondary
aQysta (Nepal) Hydro-powered water pump	Netherlands, Nepal	Nepal	**Private:** aQysta **Public:** National government; provincial governments	• Field observations in 3 SF communities • 3 interviews with representatives of aQysta Nepal • 3 Interviews with SFs **DoC**: June 2019	Gray literature
aQysta (Indonesia) Hydro-powered irrigation service	Netherlands, Indonesia	Indonesia	**Private:** aQysta **Non-profit:** Yayasan Komunitas Radio Max Waingapu (YKRMW)	• Field observations in 6 SF communities • 1 interview with representative of aQysta Indonesia • 2 interviews with representatives of YKRMW • 4 interviews with SFs **DoC**: July 2019	Scientific and gray literature
Futurepump Solar pump	UK, India	Ethiopia, Kenya	**Private:** Futurepump; national distributors; Kijani testing (field testing service) **Public:** National governments **Non-profit:** PRACTICA (research and innovation)	• 1 interview with representative of Futurepump • 1 interview with representative of PRACTICA **DoC**: March 2021	Gray literature
Sesi Technologies Grain post-harvest products and services	Ghana	Ghana	**Private:** Sesi Technologies; partner companies (providers of specific products/services)	• 1 interview with representative of Sesi Technologies **DoC**: August 2021	Gray literature
(B)energy Biogas systems	Germany	Rwanda	**Private:** (B)energy; national distributors	• 1 interview with representative of (B)energy **DoC**: June 2021	Gray literature
Dimitra Farm management platform	USA	Uganda, Nigeria	**Private:** Dimitra; farmer associations **Public:** National governments **Non-profit:** Agricultural NGOs	• 1 interview with representative of Dimitra **DoC**: August 2021	Gray literature
Agricultural Development Bank Limited (ADBL) Agricultural microcredit	Nepal	Nepal	**Public:** ADBL; national government	• 1 interview with representative of ADBL **DoC**: June 2021	Gray literature
Organization X[c] Micro-insurance against extreme weather events	Zambia	Zambia	**Private:** Organization X; partner companies (providers of specific products/services) **Non-profit:** NGO (advisor)[c]	• 1 interview with representative of NGO **DoC**: April 2021	Scientific and gray literature[d]

TABLE 1 (Continued)

Case[a]	Locations		Actors involved	Collected data	
	Organization	SFs		Primary[b]	Secondary
MetKasekor Technologies for conservation agriculture	Cambodia	Cambodia	**Private:** Technology manufacturers and local entrepreneurs (providers of specific products/services) **Public:** National government; provincial governments **Non-profit:** Swisscontact (convener and promotor)	• 1 interview with representative of Swisscontact **DoC:** April 2021	Gray literature
MORINGA Agricultural inputs and services	Indonesia	Indonesia	**Private:** Multinational companies (providers of inputs); local agribusinesses (providers of specific products/services) **Non-profit:** World Vision | Wahana Visi Indonesia (convener and promotor)	• 1 interview with representatives of World Vision | Wahana Visi Indonesia **DoC:** May 2021	Gray literature

Abbreviation: DoC, date of collection.
[a]The case comprises information about the organization (in bold letters) and the type of product/service offered.
[b]Due to privacy concerns, specific positions of interviewees are intentionally kept anonymous.
[c]The interviewee of this case asked for complete anonymity of the case.
[d]Due to requested complete anonymity, these secondary sources are not listed in the references.

awareness among SFs (Phiri et al., 2019), especially in 'media dark' areas (Prahalad, 2005). This may explain why both cases also bring information closer to SFs through local agricultural fairs and events. Both firms use social media platforms too. The effectiveness of platforms, however, largely depends upon rural internet penetration rates, digital literacy of SFs and accessibility to related equipment (Phiri et al., 2019).

Local networks and word-of-mouth may be more effective ways to make information accessible to SFs (Ndimbwa et al., 2021; Phiri et al., 2019). Actors from these networks are geographically closer to SFs and usually represent more trustable faces too. Cases that apply these strategies to reach users are the BP in Indonesia, Sesi Technologies, (B)energy, Organization X, MetKasekor and MORINGA. The work of Sesi Technologies in some communities made neighboring leaders request similar services in their villages. The multitier model of (B)energy operates through local networks: national distributors look for producers, whereas producers and installers identify end-users. Organization X informs SFs directly through its own field staff about the micro-insurances. Both MetKasekor and MORINGA operate through awareness campaigns and intermediate service providers located close to the SFs. According to Poole (2017), there is the risk of local retailers acting on their own interest. They can be more interested in selling their own stock rather than becoming a source of information for SFs.

SFs oftentimes prefer 'seeing is believing' to make decisions (Hansen & Roll, 2016; Kondylis et al., 2017; Ndimbwa et al., 2021; TechnoServe, 2017). This approach works through demo plots or agricultural shows. This is an effective and popular way to demonstrate the effects of products or services. Moreover, it does not involve any financial risk for the SFs (Ndimbwa et al., 2021; Yigezu et al., 2018). Futurepump, (B)energy, MetKasekor and MORINGA use demonstration plots to showcase their products and services. (B)energy has installed systems in local markets and villages for SFs to see how it works. MORINGA sets demo plots by pooling funds from a private company, land from the community, and labor from the intermediate service provider.

Learning through early adopters is a particular case of on-site demonstrations. Its main advantage is that early adopters are likely the closest and most familiar actors to SFs. On the downside, its effectiveness may be affected by other intervening variables (e.g., farm characteristics, soil types, level of education, etc.). These demonstrations also may transmit not only the benefits but also the disadvantages and risks of certain innovations (Chavas & Nauges, 2020; Conley & Udry, 2010; Maertens, 2017). Futurepump has spearheaded its pumps in some communities through local leaders. MetKasekor's early adopters showcase the technologies on their own farmlands. MORINGA identifies existing local retailers that become early adopters within their existing business.

4.2 | Capital and financial services

Access to capital is a key enabling factor for SFs to unlock their potential (Rahman & Smolak, 2014). Meeting certain financial capacity

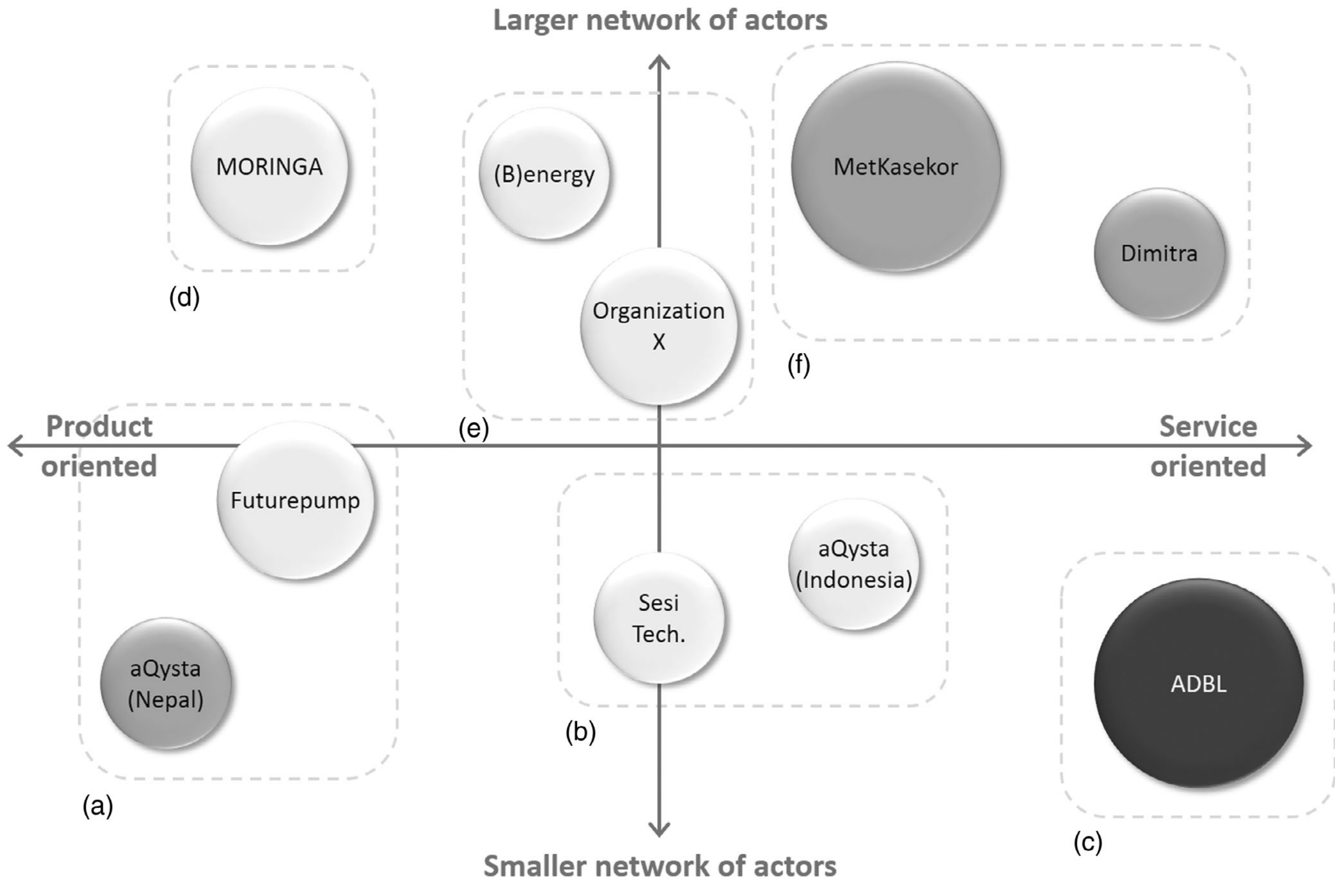

FIGURE 3 Conceptual classification of case studies across axes of product/service-oriented models and complexity/size of network of actors. The relative size of the bubbles is an indication of the size of the organization(s) involved. Light gray, medium gray, and dark gray colors of the bubbles represent the majority participation of private, public-private, and public actors, respectively. Dotted-line rectangles and letters (a, b, c, d, e, f) represent clusters of cases across the axes.

guarantees SFs access to appropriate agricultural technology, high-quality inputs, and better markets. Securing financial resources for SFs has a direct impact on increasing their productivity and revenues, and consequently in the dynamics of the local economy (Isaga, 2018; Shepherd, 2007). Limited access to capital, however, remains one of the most ubiquitous and evident challenges for SFs (Isaga, 2018; Langyintuo, 2020). Financial institutions usually consider SFs not creditworthy clients. These institutions thus seldom offer financial products tailored to SF's needs. This exclusion is rooted in too high transaction costs due to remoteness and dispersion, too long return-of-investment periods, underdeveloped infrastructures, and high risks linked to extreme weather events, volatility of prices, lack of access to inputs, and underdeveloped value chains (Isaga, 2018; Langyintuo, 2020; Rahman & Smolak, 2014). Due to this exclusion, which is more exacerbated in women (Marks, 2019), SFs tend to rely on informal credit sources like friends and relatives, remittances or even loan sharks (Isaga, 2018; Tchewafei et al., 2020). To bridge that gap in the traditional banking systems, some authors (Chen et al., 2015; Fan et al., 2013; Langyintuo, 2020; Miranda et al., 2019; Yi et al., 2021) have explored and proposed innovative options such as credit guarantee schemes, value chain financing (e.g., contract farming), and warehouse receipt financing.

Products and services are typically offered to SFs on upfront payments. Cases that operate under this scheme are the BP in Nepal, Futurepump, Sesi Technologies, (B)energy, MetKasekor and MORINGA. This model assumes that SFs belong to a customer segment with higher purchasing power and/or access to formal credit (Prahalad, 2005). In contrast, the payment capacity of many SFs shows much more limited out-of-pocket money. Their cash availability fluctuates seasonally, usually linked to agricultural production and sales of produce (Langyintuo, 2020; Oluwatayo, 2019). Due to that cash fluctuation, some providers opt to offer their products or services on (micro)credit basis. The most evident is the case of ADBL's SF-tailored microcredits. The repayment plans are sensitive to the intermittent cash flow of the clients. Futurepump's distributor in Kenya cooperates with Equity Bank Kenya to offer its products with these payment facilities. Dimitra offers SFs to pay monthly/annual fees, or on-demand (in specific trading points over time), whereas the middle organization bears the bulk upfront payment. MetKasekor and MORINGA consider the options of flexible arrangements, which may involve the participation of microfinance mechanisms.

TABLE 2 Overview of business model structure of cases, regarding their value proposition, creation, delivery, and capture.

Case	Value: Proposition	Creation	Delivery	Capture
aQysta (Nepal) Hydro-powered water pump	**PE**: Low-cost pressurized irrigation to enable higher productivity **PL**: Carbon-free water pumping technology **PR**: Robust, ready-to-use water pump	**KA**: BP demonstrations, installation, and servicing **KR**: Staff, own capital, spare parts, vehicles, and tools **KP**: Governments, retailers	**CS**: SFs in hilly areas close to water streams **CR**: Direct delivery of BP to SFs; servicing for a 2-year period **CH**: Direct communication between SFs and aQysta office, retailers, and/or governments	**CO**: Rent, salaries, BP importing, in-country transportation **RS**: BP sales
aQysta (Indonesia) Hydro-powered irrigation service	**PE**: Enabler of cash cropping to improve livelihoods **PL**: Sustainable agricultural practices **PR**: Bundle of agricultural irrigation products and services	**KA**: Installation and servicing of BP and irrigation system; delivery of inputs; capacity building **KR**: Staff, donors' capital, BP, irrigation infrastructure, inputs, vehicles, and tools **KP**: YKRMW, donors, Dutch and Indonesian universities	**CS**: SFs in hilly areas close to water streams **CR**: Frequent contact between YKRMW and SFs **CH**: Direct communication between SFs and YKRMW	**CO**: Rent, salaries, BP importing, in-country transportation, sourcing of inputs and parts **RS**: Project donations, fraction of SD harvest sale
Futurepump Solar pump	**PE**: Low-cost pressurized irrigation tailored to improve SF's productivity **PL**: Carbon-free water pumping **PR**: Robust, ready-to-use water pump	**KA**: Marketing, manufacturing, and shipping of solar pumps to distributors; continuous research and innovation of solar pumps; training to distributors **KR**: Staff, own capital, venture capital, (spare) parts of solar pumping systems **KP**: National distributors, local retailers, Kijani testing (field testing service), PRACTICA (R&D NGO), governments, NGOs	**CS**: SFs operating ≤2 acres (∼0.80 ha) **CR**: Delivery of pumps to distributors, governments, or NGOs; these provide solar pumps to SFs **CH**: Direct communication between SFs and distributors, governments, or NGOs; social media; agricultural fairs	**CO**: Rents, salaries, production and shipping of solar pumps and parts, stock keeping, marketing **RS**: Sales of solar pumps to distributors, governments, and NGOs; grants; SF payments in projects (usually in-kind)
Sesi Technologies Grain post-harvest products and services	**PE**: Increase of competitiveness and income of SFs by improving postharvest handling of grains **PL**: Reduction of food losses by increasing the quality and lifetime of grains **PR**: Delivery of a customizable bundle of grains' postharvest products and services (i.e., Farmer Pack)	**KA**: Timely mobilization of machinery (thresher, dryer) to SF communities, timely availability of staff, informing SFs about the availability of resources **KR**: Investment capital, staff, machinery, vehicles **KP**: Suppliers of machinery and inputs, financial institutions, donors	**CS**: Grain SFs, with certain degree of sensitization about the benefits of the Farmer Pack **CR**: Direct relation with the SFs; Sesi Technologies goes directly to the communities (37 so far) **CH**: Direct communication between Sesi Technologies SFs (on-site) and suppliers; word-of-mouth through local leaders and farmer networks	**CO**: Investment and maintenance in machinery and vehicles, salaries, and purchase of other products included in the bundle **RS**: SF payments (either in cash or in grain, flexibly)
(B)energy Biogas systems	**PE**: Improvement of quality of life of farmers and community members by stimulation of local entrepreneurship and provision of clean cooking	**KA**: Manufacturing and sourcing of biogas systems, shipping to target countries, recruitment of national distributors, marketing, and events **KR**: Capital, staff, and material resources to produce the technologies	**CS**: SFs willing and capable to invest in a biogas system, and villagers willing to cook with biogas **CR**: (B)energy has direct contact with national distributors, installers, and end-	**CO**: Production costs, rents, salaries, utilities, administrative costs, international shipping **RS**: Sale of biogas products (biodigesters, gas backpacks,

(Continues)

TABLE 2 (Continued)

Case	Value: Proposition	Creation	Delivery	Capture
	PL: Reduction of organic waste by transforming it into biogas and organic fertilizer **PR**: Commercial biogas systems	**KP**: African Energy Chamber (investor), European suppliers and manufacturers, volunteers [i.e., (B) Angels], other biogas companies (coordination in the sector)	users (during training); remote contact with the different user levels through app **CH**: Main contact points are done through a multi-tier scheme, where each actor connects with the following; (B)energy app to convey information to all the user levels; demos in villages	stoves), events (training, speeches, etc.), training for installers
Dimitra Farm management platform	**PE**: Increase of SFs performance and competitiveness, by enabling them to manage their operations and best practices in a more efficient manner **PL**: N/A **PR**: Provision of a platform for SF operations management	**KA**: Design and technical delivery of the system, technical support and training, development of new technologies, refinement of current designs, marketing to organizations **KR**: Own capital, staff (developers, sales, marketing), tools and resources, ICTs **KP**: Organizations, farmer associations, governments, developer companies, financial groups	**CS**: SFs operating ≤4 ha, with interest in applying technology to manage and improve their operations **CR**: Constant SF feedback collection through the platform; improvement of the systems and rollout of new versions **CH**: Dimitra has direct contact with organizations, farmer associations, governments, and financial groups. The contact with SFs is through the middle organizations	**CO**: Rent, salaries, labor, ICTs, and equipment **RS**: Through farmer associations, organizations, or governments (SFs access the services paying periodic fees, on-demand, or charity)
ADBL Agricultural microcredit	**PE**: Increased SF access to affordable and tailored capital that enhances investment capacity **PL**: N/A **PR**: Agricultural microcredit for SFs	**KA**: Training of staff in SF assistance; processing of documentation to qualify credits; marketing through different channels **KR**: Own capital; staff; physical assets in offices; ICT equipment; office branding material **KP**: International donors; international development banks; reinsurance providers	**CS**: SFs (<0.5 ha farm and < 2500 NPR income) **CR**: SFs go directly to ADBL branches to request assistance, request credits, and do the repayments **CH**: Traditional media (TV and local FM radio, in both national and local languages), written material, social media, merchandising, official website, events at provincial and local levels	**CO**: Rent, salaries, operation costs (loan monitoring, supervision, and collection), ICTs, energy (diesel generators) **RS**: Interest rates of ∼3%–3.5% (actual rate is ∼8.5%, government subsidizes ∼5%)
Organization X Micro-insurance against extreme weather events	**PE**: Increased SF resilience by providing financial protection against extreme weather events **PL**: N/A **PR**: Bundle sales of individual micro-insurance (alongside other agricultural products and services)	**KA**: Establishment of the contract farming scheme; 100% upfront pre-financing of insurance premium; delivery of bundle to SFs; claiming and distribution of payouts; settling of payments by the end of season **KR**: Staff, own capital, loans capital, inputs; vehicles **KP**: Insurance provider; inputs providers; brokers (iNGOs); banks	**CS**: marginalized cotton SFs **CR**: SFs are aggregated under a contract farming scheme; close contact between SFs and agribusiness **CH**: Direct, on-field communication between SFs and agribusiness	**CO**: Rent, salaries, sourcing of insurance and inputs **RS**: Cotton sales by the end of season
MetKasekor Technologies for	**PE**: Improved SF farm productivity by accessing to affordable agricultural services and capacity building	**KA**: Training to provincial governments, and from these to service providers;	**CS**: SFs close to service providers	**CO**: Salaries, mobilization, and training, meetings, and workshops

TABLE 2 (Continued)

Case	Value Proposition	Creation	Delivery	Capture
conservation agriculture	**PL**: Sustainable intensification of agriculture **PR**: Creation of market for six agricultural technologies and other related products and services	networking with private suppliers of agricultural products and services **KR**: (Training) staff, public budget, agricultural technologies, and inputs **KP**: Provincial governments, private suppliers, service providers (early adopters)	**CR**: SFs receive products and services from service providers, who are early adopter SFs **CH**: Periodic evaluation meetings between national and provincial governments; training sessions from provincial governments and private companies to service providers; contact between service providers and SFs at local level	**RS**: Public funds (national annual budget); SFs pay to local service providers (flexible dealings between these actors)
MORINGA Agricultural inputs and services	**PE**: Improved SF incomes and livelihoods by building capacities on better agricultural practices and linkage to agricultural value chains **PL**: N/A **PR**: Increased demand for specific agricultural inputs	**KA**: Identification of intermediate service provider; funding of demo plots; networking with buyers **KR**: Staff, own capital, agricultural inputs, agricultural technologies, and inputs **KP**: Broker (iNGO), national retailers, intermediate service provider (local agri-shop), local social and religious leaders	**CS**: SFs close to service providers **CR**: SFs receive products and services from service providers, who are existing agri-shops at local levels **CH**: Meetings and workshops for SFs; marketing through service provider; word-of-mouth through local leaders	**CO**: Salaries, mobilization and training, meetings and workshops, transport of inputs, setting of demo plots **RS**: Sales of inputs to service providers; SFs pay to them on flexible basis (upfront, credit, in harvest)

Abbreviations: CH, channels; CO, cost structure; CR, customer relationships; CS, customer segments; KA, key activities; KP, key partnerships; KR, Key resources; PE, People; PL, planet; PR, profit; RS, revenue streams.

Microfinance institutions may cater to specific needs of SFs, but those have limitations. They usually bear limited capital, smaller outreach, and high-interest rates. They can be unreachable to SFs if located in urban areas. Their repayment schedules do not always match with the seasonality of SFs' cash flows (Dossou et al., 2020; Langyintuo, 2020; Shepherd, 2007). Microfinancing through farmer associations at times copes with these limitations. These associations are locally present, involved in the farming businesses, and can provide their SFs with on-credit products and services (Bizikova et al., 2020). In addition, associations have stronger capacities than individual SFs to negotiate better prices of products and services (Bizikova et al., 2020). At the same time, associations may experience difficulties in enforcing loan repayment among their associates (Shepherd, 2007).

Subsidies make products and services more affordable for SFs. These can come as public subsidies (as defined in a public policy) or through private, donor-driven projects. ADBL and the BP in Nepal leverage on subsidies provided by the Government of Nepal. These instruments subsidize roughly 5% of ADBL's microcredits for SFs, and up to ~90% of the BP. Futurepump (in Ethiopia) (GIZ, 2020), Sesi Technologies (Siemens Stiftung, 2020), Dimitra and the BP in Indonesia reach SFs through donor-driven subsidies. In Futurepump in Ethiopia, SFs additionally contribute in-kind (e.g., land, labor, maintenance, showcase). Subsidies are not free of pitfalls. Mismanaged subsidies can compromise the financial sustainability of local economies. That mismanagement can result in market distortions, unrealistic costs of products and services, asymmetric competition with local entrepreneurs, and misuse of external funds ((B)energy, 2021a; Gurung et al., 2013; Khatiwada, 2020; Shepherd, 2007).

Pay-with-harvest has recently emerged as a financing mechanism for SFs (Tibbo et al., 2020). In this model, SFs pay with (a fraction of) their harvest to access products and services. The model can be combined with traditional cash payments and/or microcredits. The payment can be agreed upon as a percentage of the total production (rather than a fixed amount of produce), mitigating the SF's financial after a harvest failure (Tibbo et al., 2020). The BP in Indonesia, MetKasekor and Sesi Technologies offer these payment options. The latter offers the most flexibility to the users: the SF chooses the percentages of cash/harvest payment, and the type of services that will be paid for. Operating through a contract farming scheme (Ruml et al., 2022), Organization X settles the cost of the bundle of products and services—including the micro-insurance—when collecting the produce from its SFs. This is done at the end of the season, so SFs do not make any payments upfront. Side-selling (i.e., sales to other non-committed buyers) is one of the most prominent challenges in pay-with-harvest models, and is even more sensitive when contracts are mediating (Casaburi & Willis, 2017; Tibbo et al., 2020). By side-selling, SFs may not meet pre-agreed harvest volumes, which can turn into financial losses for products/services providers.

4.3 | Training and capacity building

The SFs' decision to adopt agricultural practices is largely influenced by their knowledge and skills (Stewart et al., 2015). Training is a means to strengthen SFs' capacities, which facilitates the uptake of new products and services (Pratiwi & Suzuki, 2020). Training takes various forms depending on their content, duration, participation level, and type of training provider (Pratiwi & Suzuki, 2020; Stewart et al., 2015). The combination of those factors results in different training approaches. Examples of those approaches are the typical 'train and visit' governmental extension services, and the more participatory farmer field schools (Stewart et al., 2015). Moreover, in recent times several context-sensitive training approaches have emerged, as De Janvry et al. (2017) report. The effectiveness of these interventions varies depending on the target SF, the community (De Janvry et al., 2017), and the training location itself (Nakano et al., 2018; Pratiwi & Suzuki, 2020).

Sesi Technologies and Organization X train their SF users directly. Sesi Technologies makes it possible due to its decentralized structure of services, which are delivered as closely as required to the SFs. Organization X trains SFs through its own field staff in frequent touch points throughout the season. These interactions are largely used to inform and train SFs on the micro-insurance and other products and services included in the contractual arrangements. Additionally, given the immaturity of the micro-insurance market, Organization X also counts on development aid organizations to build capacities of insurance providers, agribusinesses, and SFs.

Most firms studied here do not provide direct training to SFs. Training them directly would bear costs that likely neither companies nor SFs can afford (Nakano et al., 2018). These companies rather upskill intermediary actors, who then cascade down knowledge to SFs through further interactions. aQysta trains its staff at the national branch in Nepal. Based on training from aQysta, the service provider of the BP in Indonesia took over the operation of its pumps. Futurepump offers training to their national distributors, like David & Shirtliff in Kenya (Davies, 2018), to support SFs. Futurepump has trained extension officers in Ethiopia through NGOs (GIZ, 2020). (B)energy offers direct capacity building to its national distributors, installers, and end-users ((B)energy, 2021b, 2021c). Dimitra trains the middle organizations that acquire their services and make them available to SFs (Dimitra, 2021). ADBL ensures an equal level of preparation in all its branches throughout the country. MetKasekor and MORINGA train their respective local service providers (who at times are SFs), which is reported as a more effective local capacity building mechanism (Nakano et al., 2018).

Futurepump and (B)energy provide remote training to cope with their users' geographical distance, dispersion, and/or remoteness. Futurepump has a comprehensive set of videos about its products' installation, operation, and maintenance. (B)energy administers a proprietary application and online training (videos with subtitles) for installers, and online training for SFs. The installers can receive direct troubleshooting from the distributor through the application. Moreover, if required, distributors can contact (B)energy headquarters in Germany for further assistance. The use of digital platforms and applications is an effective and affordable way to massively roll out new information to the users. However, the digital divide due to limited internet penetration (Villapol et al., 2018), limited access to ICT equipment and electricity (Armey & Hosman, 2016), and/or (digital) illiteracy (Jere et al., 2013), can pose a substantial challenge to implement these strategies.

4.4 | Rural logistics and supply chains

A large extent of literature focuses on how to connect SFs to well-developed markets (addressed in the following subsection) (Akter et al., 2021; KC et al., 2020; Poole, 2017; Sher et al., 2020; Tessema et al., 2019). However, much less of it studies the importance of rural logistics and strong supply chains in delivering key products and services to SFs. Logistics implies much more than just a one-time delivery of a physical product in SF communities. It must consider the continuous flow and timely availability of inputs, technologies and equipment (including spare parts and tools), and information and knowledge (ADB, 2017).

Provider companies deal with several challenges in delivering their products and services to SFs (Fowler & White, 2015). First, they may be less encouraged to supply capital-constrained SFs, as compared to larger, riskless users (e.g., governments, agribusinesses, farmer cooperatives, and large farmers). Second, they may see SFs as an unattractive market due to dispersed demand, deficient road infrastructure, and costly transportation. Third, they may refrain from engaging commercially with local retailers showing marketing mismanagement (e.g., failing in bookkeeping and managing inventory). Furthermore, cash limitations may restrict their investment efforts in outreach activities (e.g., promotional activities, stocking inventory, opening local stores). Lastly, lack of mutual trust between providers and SFs may hinder an otherwise beneficial long-term, strong relationship.

Our cases use different strategies to (partially) cope with the challenges above. aQysta delivers the BP in Nepal through its national branch. Due to using its own staff and logistics, however, aQysta faces the constant issue of remoteness and extended traveling times in Nepal. Futurepump relies on well-positioned national distributors and/or their regional branches. (B)energy counts on active installers, who market the technology locally. Futurepump and (B)energy also train local actors (i.e., extension workers, and technicians), so SFs can access their knowledge as closely as possible. ADBL delivers its services through hundreds of branches throughout Nepal (ADBL, 2022). MetKasekor and MORINGA train early adopters and local retailers, respectively, so these can act as sub-district- or village-level service providers. In a similar line, the BP in Indonesia is made accessible to SFs through a local service provider; however, its supply chain from the Netherlands is not formally established and thus relatively fragile. Sesi Technologies, on the other hand, is the only case that provides its FarmerPack directly at village level, without the intervention of intermediate actors. In fact, due to its bundle of products and services, Sesi Technologies can be considered as the intermediary of many other suppliers of machinery and inputs.

4.5 | Connection to markets

Pure subsistence farming barely exists nowadays. Even the most marginalized SFs are linked to agricultural markets. They participate with their cash flows, purchase products and services, and contribute to the supply of foodstuffs (Poole, 2017). This linkage, and the growing global demand for their diversity of produce, bring them opportunities to improve their incomes. At the same time, many market challenges, prevent SFs from being competitive and from seizing those opportunities (Markelova et al., 2009; Odero-Waitituh, 2021; Wiggins, 2020). Lack of pricing information oftentimes place SFs at a disadvantage regarding intermediaries and other third parties. Too costly procedures may leave SFs out of some niche markets (e.g., certifications for organic or fair trade). Poor road networks limit the acquisition of inputs and transportability of produce while increasing postharvest losses. The volatile rural market environment usually involves high marketing costs, and prices subjected to fluctuant supply and demand dynamics. Lastly, weak institutional and policy frameworks may exacerbate all these distortions.

Private businesses, especially smaller ones, may have extremely limited influence on the macro factors that condition agricultural markets. These companies usually cannot invest in improved public road infrastructure. They cannot steer international prices of agri-commodities. Their business advocacy to steer agricultural policies is rather limited. Nonetheless, companies can implement strategies to adapt better to those market conditions, or even to cope with those restrictions. The local provider of the BP in in Indonesia guarantees SFs a market for their produce. Organization X provides its SFs with off-take contracts that set buying prices at the start of the season. MORINGA maximizes SF profits by identifying agri-commodities with the highest commercial potential, and by connecting producers with potential premium buyers. Sesi Technologies and Dimitra provide information about prices and buyers through their respective channels. These two organizations also promote higher, more competitive produce quality that enables SFs reaching higher selling prices. Sesi Technologies accomplishes that goal by providing a bundle of value-adding postharvest services (i.e., drying, threshing, storing), whereas Dimitra facilitates SFs in managing the traceability of products to meet certain standards (e.g., to export livestock). Lastly, (B)energy, MetKasekor and MORINGA directly stimulate the local economic dynamics by providing entrepreneurial support to intermediate providers.

5 | LESSONS FOR THE BARSHA PUMP

Both aQysta and its BP are newcomers in the world of water pumping (aQysta, 2022a). Neither of them is common knowledge among SF communities. The company resorts to three ***information and knowledge*** strategies: web-based channels, on-site demonstrations (targeting mainly sectional governments), and showcasing at agricultural events. However, ICT divides and physical remoteness of SFs may result in information not reaching them. Information on the BP could be made more easily available to SF communities through intermediate actors (e.g., local agribusinesses, farmer groups, NGOs) and/or local early adopters. These actors ensure more effective outreach through word-of-mouth and 'seeing is believing'.

SFs stressed the BP's virtually-zero operation costs as one of its most salient features. This characteristic is more relevant when compared to cost-demanding fuels required by petrol pumps. However, this feature is overshadowed by its relatively high upfront costs. The BP's floating variant (installed on-site) costs about 1300 EUR in Nepal and 1800 EUR in Indonesia,[5] with equivalent petrol pumps costing roughly 200 EUR and 370 EUR, respectively. This means that, without adequate access to ***capital and financial services***, the BP can be quite unaffordable for SFs despite its 2-year break-even point (aQysta, 2019). Although aQysta leverages on subsidies to make the BP more affordable, these instruments tend to favor other renewable energy technologies [e.g., solar pumps in the Eastern Gangetic Plains (Bastakoti et al., 2020) and Ethiopia (GIZ, 2020)]. Additionally, diesel and solar pumps –more compact and transportable than the BP– enable more easily mobile (i.e., on bikes and motorbikes) and affordable pay-as-you-go SF irrigation services. Examples of such initiatives are JOHAR (Nitnaware, 2021; Singh et al., 2020), SunCulture's Pay-As-You-Grow (ARE, 2021), PAY-N-PUMP (PAY-N-PUMP, 2021) and Agriworks Uganda (Agriworks Uganda, 2022). Consequently, the BP must compete in markets with more affordable and better-positioned pumping technologies. The BP could find financial support in microfinance institutions, and/or in microcredits facilitated by agribusinesses through contract farming schemes. However, the main challenge of this strategy is that such actors may be reluctant to operate with an unfamiliar technology.

The BP bears a straightforward pumping principle, a simple and robust design, and a few-component construction. Despite that simplicity, without proper ***training and capacity building***, SF users might not easily relate to BP's installation, operation, and servicing. Unless local actors are properly trained, the BP operation in SF communities can turn logistically complex. This complexity can be further exacerbated if the required knowledge is based in urban centers far from SFs (e.g., Kathmandu in Nepal). aQysta could train intermediate, village-based actors as local BP servicing providers. These actors can be existing retailers and/or SFs with required technical predispositions and skills. Nonetheless, aQysta still needs to meet a minimum density of BPs per area to justify the investment in training of these local actors.

The BP's value proposition is higher in remote, off-the-grid locations. Under such conditions, diesel pumps fall behind as competitors due to weak or inexistent fuel supply chains. In lack of robust ***rural logistics and supply chains***, this advantage turns into a paradox: the more valuable the BP is, the more burdensome its servicing may become. Two strategies can improve BP's servicing in remote areas. The first one is to produce spare parts as locally as possible. Some components (e.g., the waterwheel paddles) can be manufactured with local, low-cost methods. This strategy can be supported by using market-standard components (e.g., screws, aluminum, bolts and nuts) available in local markets. Off-the-shelf components from local stores can replace unique parts (e.g., standard diaphragm pumps and gearboxes, instead of spiral pipes), though this requires additional redesign efforts. This strategy shortens required supply chains, ensures availability of parts, and potentially stimulates local jobs. The second strategy is to leverage on existing supply chains of other actors. By collaborating with stakeholders that already operate with robust logistic networks (e.g., agribusinesses, NGOs, farmer cooperatives), aQysta can boost the timely availability of expertise and components.

The BP can be an ideal irrigation device under certain farm conditions (i.e., size, crops, distance from water source). However, as it occurs with any other water pump, its sole use is not enough to close logistic, financial, and information gaps that SFs usually face in their ***connection to markets*** (Lee et al., 2012; Markelova & Mwangi, 2010; Poole, 2017). This is a common shortcoming of technology transfer models whereby the device is seen as a trouble-shooting black box supposed to work in every context (Glover et al., 2017; Glover et al., 2019; Röling, 2009). In this respect, the BP should become less central within the value proposition of aQysta. The BP could be more in line with other products and services equally important for SFs, for example, inputs, machinery, knowledge, produce off-taking, and so forth. Provided that aQysta cannot become a holistic provider, this paradigm shift demands the coordinated intervention of many more actors in the value chain (Adjogatse & Saab, 2022). We can find examples of such synergies in cases described here like Sesi Technologies, Organization X, MetKasekor, MORINGA.

Recently, aQysta started shifting its business scope from a developer of hydro-powered pumps to a provider of SF farming services. Through the Grown Farm Incubator business model (aQysta, 2022b), aQysta provides SFs with on-credit agricultural inputs, technologies, services (e.g., certifications, training, advice, market connections), and even land if required. To ensure a timely cash flow for SFs, aQysta gives them advances of the predicted harvest, with costs being settled at the end of the season. SFs do not repay the advanced money in case of harvest losses due to natural disasters and climate risks. Although this model resembles that of contract farming (Ruml et al., 2022), it differs mainly in the advanced payment schemes, the share of profits between aQysta and SFs based on transparent prices, and the financing of irrigation technology (aQysta, personal communication, October 17, 2022). This new business approach has started with 50 farmers in Malawi, India and Nepal (aQysta, 2022a). A more comprehensive analysis of the Grown model could not be part of this text, but a first assessment for Malawi is available in Van Engelenhoven (2022).

6 | IMPLICATIONS FOR COMPANIES AND DEVELOPMENT

Companies providing a single product or service may address one specific need of SFs (e.g., an irrigation pump to enable SF irrigation).

[5]These are installed costs of the highest-priced version of the BP (floating variant). Other variants (e.g., standing, canal), which dispend with some components, may pose lower costs.

However, such a narrow business strategy typically fails to address the SF's multifaceted challenges (Adams & Jumpah, 2021; Akzar et al., 2023). By not reaching a higher value proposition, SFs may ultimately disregard the offered product or service. In addition, these products and services are often inaccessible or unaffordable to SFs due to various obstacles. As a result of this pernicious loop, the company struggles in generating profit, and the impact created at SF level is practically negligible.

Innovating towards SBMs may offer companies new business opportunities and a better financial resilience. At the same time, it involves the complexity of enhancing the value proposition towards the threefold goal of (1) attaining revenues, (2) improving SF's well-being, and (3) contributing to preserving the environment (Geissdoerfer et al., 2018). First, profit considerations need to recognize that SFs differ from wealthier population segments (e.g., large-scale commercial farmers). SFs typically cannot afford more expensive products and services. When engaging with SFs, prioritizing small margins from a broader SF base is more advantageous than seeking larger margins from a smaller segment (Prahalad, 2005). Companies should enrich their value proposition by offering additional products and services that improve SFs' productivity. Through this improvement, both SF and companies have more access to premium markets, better prices, and bigger margins.

Agri-processors can strengthen their engagement with SFs by providing bundles of products and services. Companies can act as a holistic provider or in coalition with other actors (Adjogatse & Saab, 2022). Partnerships with other providers (i.e., providers of inputs, mechanization, finance, etc.) is key for agri-processors to deliver higher value to SFs while focusing on their core business (Adjogatse & Saab, 2022; IDH, 2019; USAID, 2019). Furthermore, a good offer of products and services keeps SF's loyalty to the company, thus ensuring a steady supply of produce (Van der Velden et al., 2017). Lastly, companies should identify profitable products and services (e.g., mechanization, spraying, and high-quality inputs), which are generally easier to monetize compared to training or advisory services. An adequate balance between profitable versus less-lucrative products and services may ensure higher SF value while generating margins for the provider.

Second, when focusing on the impact on SFs, it is essential to tailor the offer to their unique needs. Examples of this offer are seed varieties resistant to specific climate conditions (Cacho et al., 2020), micro-loans with flexible repayment schedules (Dossou et al., 2020), and context-sensitive machinery (Paudel et al., 2023). By understanding those needs, companies can offer products and services that create a longer-lasting SF impact. Besides, companies must emphasize efforts on last-mile delivery strategies. No matter how impactful the products or services are if SFs cannot have timely access to them. Examples of such strategies include village-based agents (Scheer & Okelai, 2019), cascading through farmer cooperatives (Miroro et al., 2023; Sugden et al., 2021), and lead farmers liaising with SFs (Ragasa, 2020). Offering products and services comprehensible to SFs is pivotal to stimulate their uptake. Using context-sensitive communication channels (e.g., radio broadcasts, intermediaries like farmer groups or village-based retailers), can inform SFs more effectively about the availability of products and services.

Providing financial support to SFs is crucial for them to access products and services (Colina et al., 2023; Leyson & Morgan, 2022; Zook, 2014). Financial support strategies are forward contracts with SFs (including the on-credit provision of products and services) (Tabe-Ojong & Abay, 2023), and tri-partite agreements that involve financial service providers (IDH, 2023). Collaborating with grassroots structures like farmer cooperatives (Ma et al., 2022; Miroro et al., 2023; Shen et al., 2022) or village loan and savings associations (Seidu, 2017; Solidaridad, 2021) can facilitate this financial objective. Moreover, partnering with agribusinesses that source produce from SFs can secure market access and improve their long-term commercial viability (TechnoServe, 2023).

Third, to address environmental concerns, it is imperative for companies to provide sustainable products and services. For example, companies can shift towards lower environmental footprint solutions like renewable energy-powered irrigation (Lefore et al., 2021). Providers can also focus their offer to sustainably intensify SF agriculture. Among these are as high-yield and climate-resistant seeds (Cacho et al., 2020), no-till machinery (Sims & Kienzle, 2017), and practices like conservation agriculture (Lee & Gambiza, 2022). Furthermore, companies can offer products and services that favor the regeneration of agricultural ecosystems, like organic fertilizers (Muluneh et al., 2022), agroforestry practices (Duffy et al., 2021), and integrated soil fertility management (Kwadzo & Quayson, 2021).

7 | CONCLUSION

SFs are key actors in approaches aiming at reducing poverty and increasing global food production, both by public and private actors. For private actors like companies, SBMs can be appropriate instruments to bridge the many gaps that SFs face in accessing required products and services. The lack of SFs' access to information, capital, training, logistics, and market linkages affects the whole agricultural value chain. By exploring 10 cases of SBMs, we have identified several strategies that providers apply to make products and services accessible, affordable, profitable, and sustainable to/for farmers. These strategies range from leveraging on public subsidies and new channels of (digital) information to complex multi-stakeholder business ecosystems.

Using these cases and strategies, we observed the opportunities ahead for the BP as a product and for aQysta (and other similar companies) as a business. The pump can leverage on the robustness of long-standing actors to transmit timely information about its benefits. Due to its comparatively high cost, coupling the pump with access to (micro)financial services to achieve affordability is recommendable. Training on commissioning and servicing the BP can be achieved through existing intermediate actors closer to SFs. Proper supply of parts and knowledge to sustain the use of the pump can build on existing logistics and market-standard components. To ensure better SFs' connection to markets, the BP as a product may need to become one of the components of a more robust SBM.

The lessons from the cross-case analysis can be connected to other products and services intended to reach SFs. We have elaborated on the implications that the strategies may have in the BMs of other companies engaging with SFs. These companies must consider several business strategies in pursuing the threefold enhancement of their SBM's value proposition. More research on innovations in SBMs is necessary to measure the impact that the implementation of strategies may have in improving the livelihoods of SFs, while promoting environmental protection, and ensuring long-term financial profitability of product/service providers.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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