THE 2023

IASDR Congress

Life-changing design

Milan 9th—13th October

PROCEEDINGS OF IASDR 2023

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Life-Changing Design

Proceedings of the 10th Congress of the International Association of Societies of Design Research (IASDR 2023)

EDITORS:

Daniela de Sainz Molestina
Laura Galluzzo
Francesca Rizzo
Davide Spallazzo

Proceedings of the 2023 IASDR Congress
International Association of Societies of Design Research International Congress
9 – 13 October 2023
Milan, Italy
www.iasdr2023.polimi.it

Cover and congress identity design by Daniela de Sainz Molestina
Proceedings compiled by Lenny Martinez Dominguez

Editors: Daniela de Sainz Molestina, Laura Galluzzo, Francesca Rizzo, Davide Spallazzo

ISBN 978-1-912294-59-6
https://doi.org/10.21606/iasdr.2023.899

Published by the Design Research Society
85 Great Portland Street
London, W1W 7LT
United Kingdom

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The Tenth IASDR congress. An Introductory Address from the IASDR Board

IASDR 2023 is the 10th biennial congress of IASDR, and the first to take place after the crisis of COVID-19. With this congress we re-confirm the importance of discussion and debate for the network of researchers in design, as well as the importance of developing younger researchers for the future of the Association.

The International Association for Societies of Design Research (IASDR) was established in 2005 through a collaboration of four academic societies: Chinese Institute of Design (CID), the Design Research Society (DRS), Korean Society for Design Science (KSDS) and Japanese Society for the Science of Design (JSSD).

The history of international collaboration in Design Research in the Asian region can be traced back to 1996 when JSSD organized the first Japan-China Industrial Design Symposium which was hosted by Beihang University in Beijing, 1996. This started a series of international conferences in design research known as the Asian Design Conference. Conferences took place in 1997 (Daejeon, Korea at KAIST), 1998 (Taichung, Taiwan at National Taichung University of Science and Technology), 1999 (Nagaoka, Japan at Nagaoka University of Technology), 2001 (Seoul by National Seoul University), and 2003 (Tsukuba, Japan at Tsukuba International Congress Center). At the 2003 congress – the 6th Asian Design Conference – the three Asian academic societies agreed to welcome the Design Research Society into a new association.

We thus begun the International Association of Societies of Design Research for the field of design research in 2005, in Taiwan. Since that time, we have enhanced the network of researchers and fields of design research and promoted design research education. We will continue to build this incomparable network of design research as we move towards our 2025 congress, at Tapei, Taiwan.

Our deepest thanks go to Luisa Collina, and the entire Politecnico Milano team who have worked so hard, as hosts for IASDR2023, to ensure its success. Your leadership throughout the process has been excellent and we think the result will be much appreciated by the IASDR design research community.

Toshimasa Yamanaka
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On behalf of the IASDR Board
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Life-Changing Design.
Introduction to the Tenth IASDR congress

The International Association of Societies of Design Research (IASDR) has long been at the forefront of advancing design research, providing an international platform for researchers, scholars, and practitioners to engage in robust discussions, share insights, and explore the ever-evolving landscape of design research. IASDR 2023, the association's 10th Congress, stands as a pivotal juncture in the trajectory of design research, offering a comprehensive perspective on its current state while charting its future directions.

Over the past decade, design research has witnessed a remarkable transformation. From its roots in aesthetic considerations and form-centric approaches, design research has evolved into a multifaceted discipline, extending its influence beyond traditional boundaries. Contemporary design literature now encompasses a wide array of facets, each addressing critical aspects of design's impact on diverse domains, including organisational culture, public policies, product development, and the creation of immersive spaces, services and systems. This transformation underscores the dynamic nature of design research, as it continuously adapts to our society's changing demands and challenges.

The central theme of IASDR 2023, "Life-Changing Design", resonates profoundly in the wake of global events, particularly the unprecedented disruptions caused by the COVID-19 pandemic. This theme invites us to reflect on the profound transformations that have unfolded and continue to reshape our world. The pandemic has brought to the forefront questions about the role of design in navigating these changes, challenging us to explore how design can facilitate adaptation, resilience, and innovation in a rapidly changing world.

IASDR 2023 has been organised and host by Politecnico di Milano, where design keeps strong roots in the made in Italy tradition and where at the same time design opens up to the new territories of design research and to the new trajectories of innovation.

IASDR 2023 encompasses an array of thematic tracks, each dedicated to exploring critical dimensions of design research. These tracks serve as focal points for discussions and investigations, providing a framework for researchers to delve into specific areas of interest.

The following thematic tracks guide our exploration:

[Changing] Organizations and Policies

This track examines the transformative potential of design in the realm of public sector organisations and policies. It aims to foster social justice and sustainability by challenging traditional notions of prosperity. Researchers investigate how design equips itself with tools, methods, and frameworks to support systemic transformation, thereby promoting well-being and addressing complex societal challenges.

[Changing] Products and Production

This track focuses on the transformation of manufacturing processes and their impact on products and

systems. It explores the proliferation of digital fabrication and digital craft, analysing their potential to revolutionise product development, sustainability, and business models. Researchers delve into how design can envision emerging materials, artefacts, and future scenarios from a sustainable perspective.

Identities and [Changing] Identities

Cultural identities and their evolution in an increasingly multicultural world take center stage in this track. Researchers delve into the roots of design's influence on identity, considering factors such as authorial identities, identity hegemony, and the implications of design on gender, class, and religion. Additionally, this track explores the role of design in translation processes, which involve revising systems, tools, and programs for communicating and preserving identity.

[Changing] Ecosystems

Addressing the imperative transition toward sustainability, this track examines how design contributes to the socio-ethical and economic dimensions of sustainability. It explores design for sustainable materials, energy, business models, and transitions, focusing on fostering positive environmental and social change.

[Changing] Communities

Community empowerment and sustainable behavioural change through design interventions are central to this track. Researchers investigate how design can enhance collaborative processes, co-design knowledge, and tools while addressing urgent public interest issues. The track emphasises shared decision-making, democratic participation, and the evolving roles of individuals, communities, and entities in supporting systemic transitions.

[Changing] Education

This track reflects on the evolving landscape of design education, recognising the complexities and challenges inherent in this domain. Researchers explore the inspirations for change in design education, the transformations it engenders, and the existing gaps and issues. This track seeks to foster clarity, identity, and adaptability in designing educational goals while embracing diversity and differentiation.

[Changing] Spaces and Services

Integrating spatial and service design to create innovative living environments and services is the central concern of this track. It explores how design interventions across various scales, from micro to macro, can drive transformative actions, enhance public participation, and guarantee inclusivity and diversity in service offerings.

[Changing] Interactions

The dynamic interplay between technology, social changes, and design forms the core of this track. Researchers investigate how digital technologies, augmented reality, virtual reality, and mixed environments impact interactions, communities, processes, and professions. This track emphasises the role of Interaction Design in shaping technology-based innovations responsive to social and contextual changes.

[Changing] Heritage

Preserving and reinterpreting cultural heritage in the face of global change is the central focus of this track. Researchers explore how design research can offer novel approaches to knowledge preservation and cultural experiences related to tangible and intangible heritage. This track seeks to activate participation dynamics that reintegrate relevant portions of cultural heritage excluded from current development paradigms.

IASDR 2023, with its overarching theme of "Life-Changing Design" and its diverse thematic tracks, presents an exceptional opportunity for researchers, scholars, and practitioners to engage with the dynamic landscape of design research. The conference serves as a platform for robust discussions, knowledge sharing, and the exploration of innovative solutions to society's complex challenges.

By examining these thematic tracks and their intersection with the central theme, “Life-Changing Design,” we aim to contribute to the ongoing dialogue surrounding design research and its transformative potential, fostering a deeper understanding of design’s role in shaping our world.

Luisa Collina
Alessandro Deserti
Francesco Zurlo

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LIFE-CHANGING DESIGN
Politecnico di Milano
9-13 October 2023

A design-driven approach to distributed ledger technologies for small farmers communities: a case study in Portugal

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doi.org/10.21606/iasdr.2023.217

Distributed Ledger Technology (DLT) has the potential to transform the agri-food sector, empowering rural and underserved farming communities by enabling the creation of a more environmentally sustainable and socio-economically inclusive food system. Several Proof-of-Concepts and pilot projects are running all over the world to test this specific use case. However, the success rate of these initiatives is still limited. A critical analysis of the state-of-the-art suggests as a possible explanation for the observed trend that the current research approach to DLT for agriculture is mostly technology-driven. This limits our ability to develop solutions that provide benefits to the communities they're meant to serve, while potentially increasing inequalities and further marginalising these underserved groups. Achieving a sustainable and inclusive food supply chain entails a paradigm shift that goes beyond technological development to address how technology is socially constructed, thus implying the need for designing DLT applications around and together with users. By adopting a user-centred perspective to technology-enabled innovation, design can help shift the agri-food industry from being tech-centred to being people-centred. To explore the potential contribution of design for facilitating transformation and technology-enabled social innovation in the agri-food sector, we conducted a case study involving Portuguese small farmers which resulted in DigiFarm, a blockchain-based service concept. In this article, we detail the methodology adopted for the scoping and ideation of DigiFarm, concluding with a discussion highlighting the added value of adopting a design-driven approach to research and practice on DLT applications in the agri-food sector.

Keywords: service design; user-centred design; small farmers; distributed ledger technologies

1 Introduction

In modern society, agriculture represents a primary source of livelihood for most households, especially in low-income and developing countries. Currently, the food demand of the growing global population is challenging the agri-food sector, leading to the intensification of production and

expansion of cultivated land. Such a change has economic, environmental, and social implications (e.g., loss of biodiversity and land abandonment) that make the sector vulnerable and potentially unsustainable, increasing the barriers for smallholder farmers to access the market (Chandrakumar et al., 2019). This is an issue, particularly for low- and middle-income countries, such as Portugal, which are characterized by a majority of small- and medium-size family farms (FAO, 2023). Agriculture has long influenced the Portuguese economy and society. Moreover, the country exited a late 41-year dictatorship in 1974, which further delayed urbanization. Small-scale and family farming is still the main contributor to the local rural economy, with around 89% of agricultural holdings being small or extra small (≥ 12,4 ha) - though numbers are declining because of internal migrations toward cities. Moreover, globally the agri-food value chain is increasingly "concentrated in fewer hands" (Tripoli & Schmidhuber, 2018, p. 6). Issues of market accessibility, financing, and the need for complying with traceability and certification standards, are limiting the ability of family farms to participate in integrated value chains (FAO, 2017).

The use of Distributed Ledgers Technologies (DLT) in agriculture and food supply chain is described in literature as a potential answer to most of the above-mentioned problems (Tripoli & Schmidhuber, 2018; Kamilaris et al., 2021; Xiong et al., 2020; Singh & Sharma, 2022). In particular, it can empower smallholder farmers - e.g., by strengthening their financial resilience (Bolt, 2019), promoting trust and mitigating transaction-related risks (Kumarathunga et al., 2022), or enabling access to global markets (Manikas et al., 2019). So far, several blockchain-based initiatives have been proposed to improve the agri-food sector. Nonetheless, most of them don't go beyond the Proof-of-Concept (PoC) and/or become inactive after a short period of time (Manikas et al., 2019). Furthermore, blockchain-based initiatives for the agri-food sector are currently being designed with a technology-driven approach, not considering to the people that the technology is meant to serve. In this scenario, we believe that design knowledge and tools can provide a significant contribution toward the development of customer-oriented solutions. Albeit scholars have successfully adopted a design-driven approach to the development of DLT (Gladyshev & Wu, 2020; Elsden et al., 2018; Rankin et al., 2020), design research on DLT for the agri-food sector is very limited, lowering the ability to design and develop effective solutions, thus potentially increasing inequalities.

In this article, we critically analyze the current approach to the design of DLT interventions for agriculture and elaborate on the contribution of design for triggering actual innovation within the sector. To do so, we present a case study involving Portuguese small farmers which resulted in DigiFarm - a DLT-based service concept. By adopting a User-Centred Design (UCD) approach in the ideation of the service, the present research aims to shed light on (i) whether and to what extent DLT interventions are currently being designed to address the actual needs of small farmers, and (ii) whether this new technology introduces new challenges that should be taken into account. By doing this, we aim to answer the following research question: Can a design-driven approach help identify limitations in current research on blockchain applications in the agri-food sector and provide useful insights to help new and existing initiatives take off?

The remainder of the article is structured as follows. Section 2 provides an overview of DLT applications reflecting on the contribution that design can bring. Sections 3 and 4 detail the methodology and ideation of the DigiFarm concept, including findings derived from its validation with relevant stakeholders. The article ends with a discussion highlighting the role of design in fostering

technology-enabled social innovation and promoting a more sustainable and inclusive agricultural industry.

2 Related Work

2.1 Distributed Ledger Technologies in the agri-food sector

DLT (like blockchain) can be regarded as a distributed database that provides a secure way to store transaction data. The database is maintained by a Peer-to-Peer, cryptographically secured network, whose participants are responsible for validating transactions and storing copies of the transaction history in a distributed fashion. Consequently, the data stored on the blockchain is transparent, immutable, and tamper-proof (Mistry et al., 2020; Zwitter & Hazenberg, 2021). Moreover, it removes the need for financial intermediaries, offering "greater cost efficiency, with lower fees and faster transactions" (Tripoli & Schmidhuber, 2018, p. 3).

The current agri-food supply chain is characterized by transparency and efficiency issues, whose repercussions affect customers and small farmers (Tripoli & Schmidhuber, 2018). The global food market - currently dominated by large-scale producers - is inherently complex and risky, thus requiring the participation of several intermediaries that results in increased costs and slow transactions. Furthermore, while consumers demand transparent information about their food purchases, the multiplicity of actors and processes involved in supply chains limits traceability and quality control (Kamilaris et al., 2021). In this context, DLT comes with the promise of bringing greater efficiency thus providing benefits to all market players by promoting inclusive market participation. Through the use of smart contracts - i.e., self-enforcing computer programs that encode an agreement between non-trusting participants (Alharby, et al., 2018) - in combination with additional technologies - e.g., NFC, and IoT - food information can be automatically collected, added to the blockchain and accessed by end-consumer (Xiong et al., 2020; Mondal et al., 2019), improving traceability and quality control (Tripoli & Schmidhuber, 2018; Rocha et al., 2021). A project leveraging such characteristics is the one designed by Borrero (2019) for the traceability of the berry production chain. His PoC uses smart contracts and permissioned ledgers to store food information (from the field to the shipping process), ensuring that all actors share the same level of information. By improving the information flow between market players, the adoption of DLT is also expected to build trust - which farmers' communities often struggle to gain (Dal Bello et al., 2022). One such case is represented by 1000EcoFarms (1000EcoFarms, n.d.), a global online marketplace that connects sellers and buyers of local natural food with the goal of bolstering their relationship. Through a built-in chat, customers can reach out to farmers and get additional information about their offer, arrange an order and share opinions about the products. Correspondently, farmers can create an online window for their business and communicate with both existing and prospective customers (FCE Media, 2017).

Ultimately, increased transparency, disintermediation and the use of smart contracts are foreseen to bring significant financial benefits, particularly to under-served communities and developing world farmers. Through DLT, farmers can build digital identities and track records to prove their creditworthiness, thus helping them to access credit (Tripoli & Schmidhuber, 2018). In 2016, Heider and Connelly (2016) estimated that around 70% of the world's population was still lacking access to proper land titling or demarcation. Traditional land registry systems are typically paper and manual labour-based; they involve many steps that increase the costs and create bureaucratic loopholes, facilitating fraudulent behavior (Alam et al., 2022). DLT can address such shortcomings by providing a

secure, immutable, and fast method to register land titles that can then be used as collateral for loan applications (Tripoli & Schmidhuber, 2018). Moreover, DLT provides farmers with frictionless and real-time payment services. Because of the low transaction volume of small-scale and family farms, "traditional e-commerce is neither willing nor able to provide services for them, thus excluding these participants from the market" (Xiong et al., 2020, p. 5). Therefore, financial transactions in the agri-food sector are still heavily cash-based (Tripoli & Schmidhuber, 2018). By switching to blockchain-based payments, risks from cash-based transactions are reduced. The removal of intermediaries such as banks, and decreased transaction fees could provide savings to farmers and incorporate them back into the market (Kamilaris et al., 2021; Xiong et al., 2020). An initiative that uses DLT to provide financial support to smallholder farmers is Agri-Wallet (AgriWallet, n.d.), a mobile digital wallet for African farmers, which can be used to save, buy input supplies, and sell products. The system works as an earmarked virtual currency. Farmers receive funds and earnings in the form of tokens which can only be spent within the agricultural supply chain, thus creating a secure form of microfinancing. Furthermore, farmers can use their Agri-Wallet to get access to earmarked loans provided by the Rabobank Foundation (Bolt, 2019).

Numerous ongoing initiatives demonstrate the DLT potential in the agricultural sector (for a review of existing initiatives see Bolt, 2019; Kim & Laskowski, 2018; Rocha et al., 2021). Nevertheless, several challenges still exist. Kamilaris and colleagues point out that most of the existing initiatives “are either in implementation phase [...] or in a proof-of-concept stage” (2021, p. 70). Indeed, only 5 out of the 80 projects included in their analysis have reached normal operation, suggesting that “convincing business cases are still scarce” (Kamilaris et al., 2021, p. 76). The limited maturity of DLT applications in the agri-food sector emerges in other survey works. For instance, Rocha and colleagues (2021) noted that most of the existing applications of DLT in the agribusiness sector are PoC and laboratory prototypes. Similarly, Tribis et al. (2018) report that almost half of the works included in their systematic literature review are solutions proposing blockchain-based frameworks, instead of real-world case studies. Collectively, existing review studies reflected a research trend focused on technology development instead of its application. Such a trend could be partially explained by the fact that most of the literature on the topic is published in the areas of Computer Science and Engineering (Rocha et al., 2021) and, therefore, is primarily focused on technical challenges. Another noted trend is that, although DLT is regarded as an important opportunity for small-farmer communities and marginalized players of the food supply chain, large-scale studies and fully-operational projects are mostly located in developed countries (Rocha et al., 2021) and run by big companies (Tripoli & Schmidhuber, 2018) - which are likely to support experimentations "involving blockchain for marketing reasons (due to the hype of this technology)" (Kamilaris et al., 2021, p. 70).

2.2 Design knowledge to support the development of DLT-based solutions for farming communities

DLT has the potential to transform the current agri-food sector, empowering rural and underserved farming communities by enabling the creation of a more environmentally sustainable and socio-economically inclusive food system. Nonetheless, we argue that such a transformation requires a paradigm shift in the design of blockchain-based products and services. Technology-enabled social innovation cannot be achieved only by focusing on the technology and its regulatory frameworks. As suggested by Murray-Rust et al. (2023), alongside solving technical challenges, research on DLT should seek to understand the social context in which the technology may be used and engage potential users in devising the socio-technical possibilities being offered by this ‘shiny new tool’. Otherwise, the risk

is to develop systems that is neither needed nor useful. Undoubtedly, such a risk characterizes the design of every new technology, but it is even more prominent when it comes to designing blockchain-based systems due to the inherent complexity of the technology. There is indeed a general lack of understanding of how DLT works, which generates misconceptions (Schneider & Azan, 2022) and makes it hard to convince farmers to give up on their old systems and processes in favour of new blockchain-based ones (Tribis et al., 2018). Moreover, small farmers lack the time, expertise, and resources to learn how to use such cutting-edge technology (Kamilaris et al., 2021). While on the one hand the hype around DLT leads big companies to experiment with DLT, on the other hand, smallholders' lack of know-how and resources is limiting their ability to adopt these systems, thereby further marginalizing rural communities and reinforcing inequality (Tripoli & Schmidhuber, 2018;).

Although there is much design and HCI research on fostering people's understanding of DLT and its social implications (Sas & Khairuddin, 2015, 2017; Elsden et al., 2018; Murray-Rust et al., 2023), there is a shortage of design-driven applications of blockchain technology in the agri-food sector. In our review of the literature, the only work that adopts a combination of design methods to devise an agri-food blockchain solution is reported in Kumarathunga et al. (2022). In their article, the authors follow a design science research methodology that involves several iterations of interviews with end-users/farmers (data gathering), scenarios creation (data analysis), prototyping and user-testing (design and implementation).

Here we argue that design can play a fundamental role in advancing research and practice on blockchain applications in the agri-food sector which may help new and existing initiatives to take off. UCD in general, and Design Thinking (DT) in particular, are "about people"; they're "about finding innovative solutions for people based on their needs" (Meinel & Leifer, 2015, p. 10). Through an iterative process of empathic research, ideas generation, prototype and experimentation (Schallmo et al., 2018), DT offers a structured yet flexible methodology to implement customer-oriented solutions. DT methods have been long applied in the field of innovation as they help integrate people's needs with the possibilities of the technology (Nash & Briggs, 2020), and ultimately bolster innovation outcomes (Liedtka, 2015). Technology-enabled social innovation does not only require a deep understanding of user needs but also their involvement throughout the entire design process. According to Manzini (2014), the very definitions of design for social innovation and participatory design largely overlap. Borrero (2019) in fact recommends engaging end-users in the design of blockchain-based solutions for the agri-food sector, highlighting the value of meeting and discussing possible use cases with relevant stakeholders to expand the agri-food blockchain ecosystem. Building on Nash and Briggs's (2020) concept of 'servant leadership', we argue that design knowledge and methods can inspire transformation in the agri-food sector, informing the design of technological solutions by bringing farmers and relevant stakeholders into the 'discussion'. Furthermore, besides structuring and facilitating co-design processes, design can identify what is still needed to "make things happen" (Manzini, 2014, p. 66). In other words, design helps synthesize communities' needs and requirements, and sheds light on the barriers preventing communities from taking full advantage of new technologies.

To demonstrate the potential contribution of design knowledge in facilitating transformation and technology-enabled social innovation of the agri-food sector, we conducted a case study involving Portuguese small farmers. Our methodological approach combines a set of UCD techniques and service design methods to guide the scoping and ideation of a DLT-based service, which in turn served

to fuel the discussion around the impact and limits of DLT technologies in small farmers communities. In the following sections, we present the methodology adopted and briefly describe the resulting service concept.

3 Methodology

For the purpose of this study, we integrated UCD and DT approaches together with a set of service design methods and tools. In particular, we followed the 5-stages Design Thinking process from the Stanford d.school (d.school, 2010) – (i) empathize, (ii) define, (iii) ideate, (iv) prototype, and (v) test. One of the most commonly used DT models, the Stanford Design Thinking model is largely influenced by the seven-stage model proposed by Simon (1969) and was chosen over the many other models available because it is perhaps the most explicitly user-centred. Indeed, by making empathy the first phase of the design process, it purposefully starts with understanding users' needs (Henriksen et al., 2020). The methods and results for each stage are outlined in the following sections.

3.1 Empathize and define

The authors empathized with the problem space and its actors through immersive primary research (Stickdorn & Schneider, 2012). Fifteen interviewees were recruited through snowball sampling: thirteen were Portuguese farmers managing small farms (4 females, 9 males, average age 53 years), while two were farmers' customers (2 females, average age 64,5 years). Interviews with farmers touched upon their business activities, motivations and challenges they face as farmers, as well as strategies, channels and technologies used to reach costumers. Customers were asked about motivations for buying local products, purchasing habits (e.g., how frequently and through which channel), and barriers typically encountered. After obtaining oral consent, the interviews (lasting around 30 min) took place over the phone or video call. Interviews were conducted in Portuguese, recorded, transcribed and translated into English. The data was coded by the second author, using NVivo software, according to Braun and Clarke's thematic analysis (2006). Results were discussed among all authors until consensus was reached. The themes highlighted from the interviews were complemented and cross-referenced with findings from a systematic review of scientific, peer-reviewed articles (published between 2016 and 2022) on the use of DLT in the agri-food sector. Finally, the data was modeled through six personas (Cooper, 1999) complemented with problem-oriented scenarios, highlighting the persona's specific issues in context. Moreover, a territory map and a stakeholder map were derived to visualise the context and the stakeholder ecology (see Figure 1).

3.2 Ideation, prototype and testing

The authors engaged in brainstorming sessions using the 10-for-10 method (AJ&Smart, n.d.) where several solutions centred around the persona's needs were generated and voted upon. The most voted ideas were then expressed through solution-oriented scenarios and articulated into one concept. The resulting service concept was unpacked through customer service journeys - one for each persona.

The service was prototyped and iteratively evaluated. Initially, users validated the set of Customer Journeys (CJ), which were then refined and mapped into a Service Blueprint (SB). Secondly, the SB was developed into an Experience Prototype (EP) (Buchenau & Suri, 2000) and evaluated with users again.

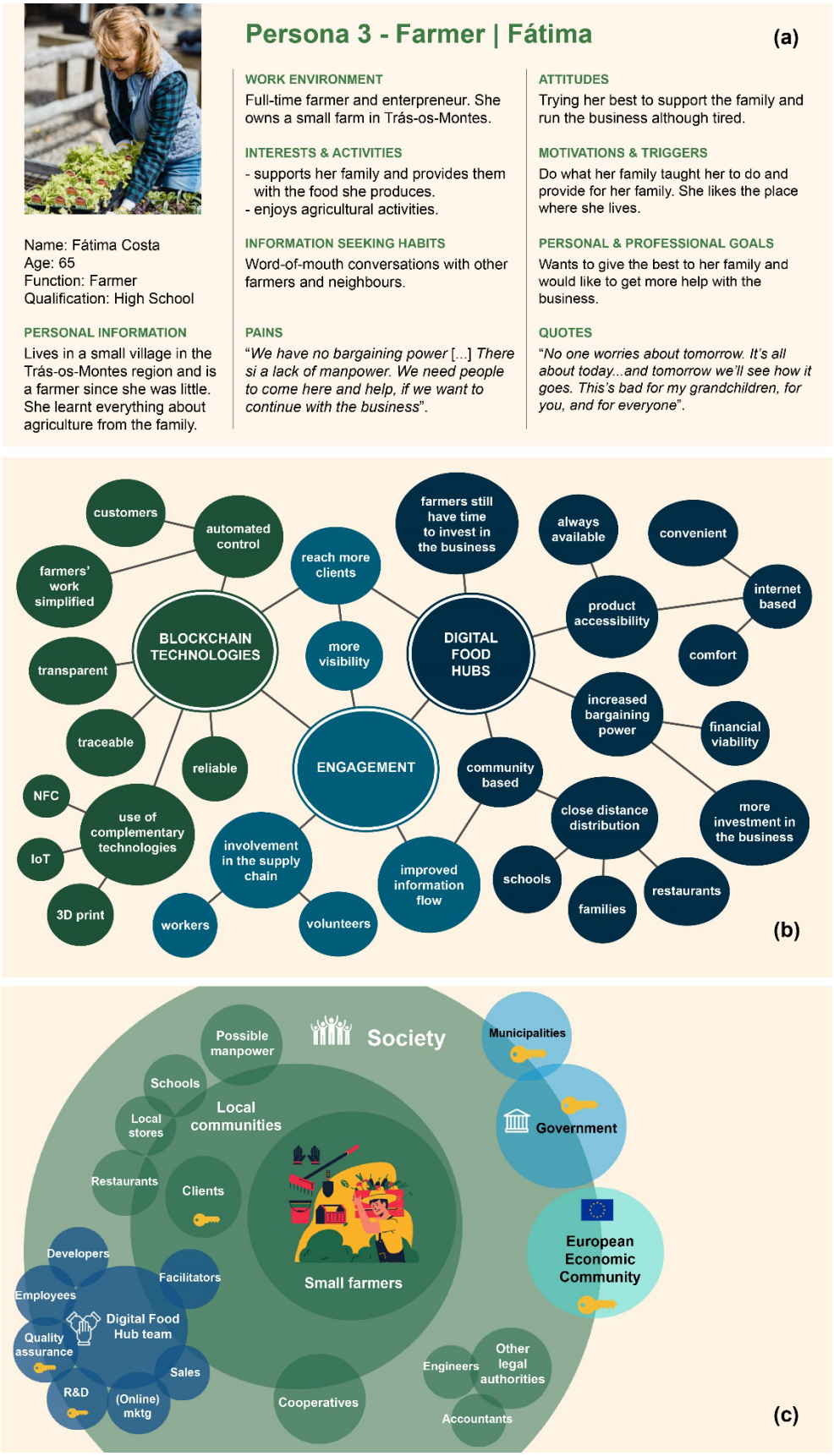

Figure 1. Some of the service design methods and tools developed throughout the study: (a) personas; (b) territory map; (c) stakeholder map.

Participants matching the personas were recruited and asked to validate the customer service journeys. Three subjects consented and took part in the study. A visit to the participants' homes was scheduled. Semi-structured interviews followed a set of walkthroughs of the customer journey maps. Questions for each dimension of the journey (awareness, research, selection, use and delivery, and follow-up (Franz, 2015)) were asked, focusing on (i) feelings and thoughts, (ii) weaknesses of the service, and (iii) opportunities and improvements. Interviews were transcribed verbatim and analyzed using an inductive–deductive approach (Swain, 2018). Individual statements were printed on separate cards and used to identify main themes and categories during an affinity diagram session (Holtzblatt et al., 2004). The researchers deliberated on the resulting themes and categories until consensus was reached. The original concept was then refined according to the feedback and developed into a SB (see Figure 2).

The SB was further evaluated to test the flow of the sequential touchpoints and the perceived value of the service (Clatworthy, 2012). For this purpose, an EP was developed, simulating the experience of specific touchpoints in sequence (Diana et al., 2012).

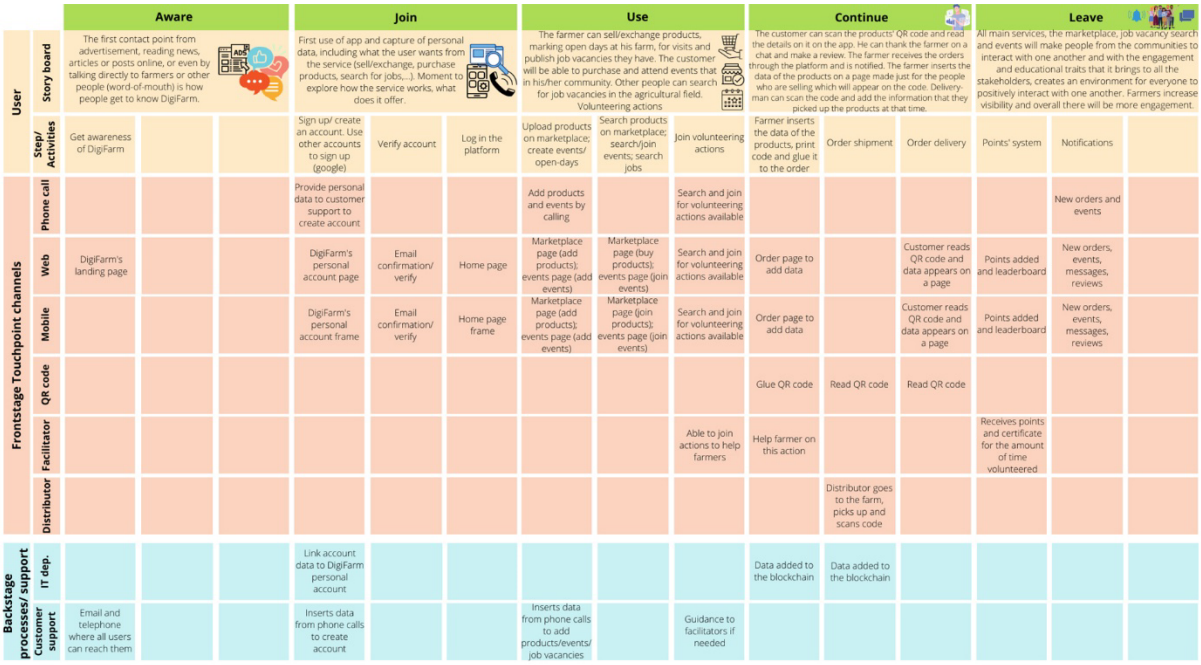

Figure 2. The service blueprint.

Two of the participants from the first round of interviews - one customer (E1) and one farmer (E2) - consented to take part in the EP study, which was conducted at the participants' homes and facilitated by a researcher. Different props (e.g., the paper-based low-fidelity prototype of a mobile app, QR codes, and a cardboard basket filled with fresh fruit) were created for the purpose of the study (see Figure 3). Data was collected through observation and notes. The think-aloud protocol was used while participants interacted with the prototype. At the end of the EP, a semi-structured interview was conducted. Similar to the first-round evaluation, the authors conducted an affinity diagram session to analyze the qualitative data, combining field notes from observations and interview transcripts. An inductive–deductive approach was adopted for the purpose of the analysis. After the data analysis, further refinements to the service were made according to the feedback gathered.

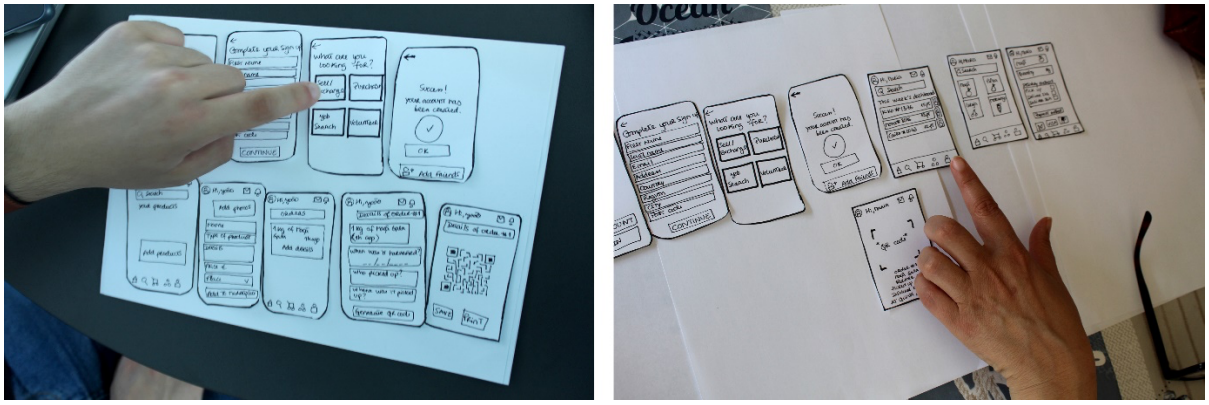

Figure 3. Participants interacting with the low-fi prototype of the DigiFarm app during the experience prototype session.

4 Results

4.1 Themes emerged from the empathizing phase

Results from this study highlight the main challenges currently faced by Portuguese small farmers and their customers. These are:

4.1.1 Lack of workforce.

More than half of the interviewees mentioned the lack of workforce in the agriculture sector as a major challenge, particularly in the interior regions of the country that are getting 'older':

> *"year after year we find fewer people willing to come and help with fruit picking" (F8)*

> *"young people leave and go somewhere else; only the older ones stay here" (F3).*

As a consequence, small farmers' have to supervise and take care of all the businesses on the farm, hence they struggle finding time to leave the farm and deliver products. The lack of manpower is reported as an issue also by literature (Manikas et al., 2019) together with the tendency of young people to flee to the urban areas (Navarro & Pereira, 2012).

4.1.2 Difficulties in reaching customers.

Most farmers reported difficulties in reaching customers.

> *"getting customers is the hardest part of running this business…and keeping them is even more difficult" (F12)*

> *"we do not produce too much; we sell too little. That's the problem" (F1).*

Evidence of this finding is backed up in literature (Dal Bello et al., 2022; Delgado, 2017). Such a challenge is due to multiple, concomitant reasons - e.g., the lack of know-how and marketing skills to promote their businesses or the tough competition with supermarkets (Berti et al., 2017)

> *"We don't have a website yet. That would be important! [...] We've tried to advertise our products on social media…but it didn't work" (F6)*

4.1.3 Lack of support from government and local authorities.

Several interviewees reported the lack of initiatives from the Portuguese public institutions to bolster the agricultural sector.

"...the municipal councils of education could push on the consumption of local and organic food in schools. This happens in several countries but not in Portugal" (F1).

Interviewees felt that public institutions could better promote local/national products

"it's very hard for farmers to continue without government support. […] authorities should put more effort into strengthening domestic production instead of relying on imports" (F12)

and educating people on the importance of eating local, seasonal food

"It's all about education. Doing preventive medicine should be of primary importance for the Ministry of Health" (F1).

This is echoed in literature, which calls for increased involvement of the public sector in supporting agricultural activities and small entrepreneurial farmers (Dal Bello et al., 2022).

4.1.4 Difficulties in winning local communities' trust.

Interviewees reported that the general lack of knowledge about farming practices and agriculture leaves the door open to fraud which, in its turn, negatively impacts customers' trust.

"There are several myths about the 'farmer next-door' out there [...] and cases of misleading or fraudulent organic claims. Often people end up being fooled. I have a lot of friends who think they buy organic but, in reality, they don't" (F1).

The need for ensuring transparency and traceability of food information is emphasized also by the literature (Rocha et al., 2021). Documenting the origin of food is a proven means to build trust (Kamilaris et al., 2021), which is particularly beneficial for small farmers (Borrero, 2019).

4.1.5 Difficulty in balancing production.

The difficulties in predicting demand, hence balancing production accordingly is combined with the problem of surplus production, which is hard to sell and thus often wasted

"The number of customers varies significantly; we have not managed to stabilize it yet so forecasting stocks is always complicated" (F2).

4.1.6 Competition of supermarkets and other retail environments

"People go to the supermarket as they can find all kinds of things there...and it is always open" (F5)

"there are a few initiatives here to help farmers selling their products. Twice a month there is the farmers market, but it's on Sundays and a few people show up. There are also fairs, like the São Pedro fair. A lot of people go there to buy products...but it happens only once a year" (F9).

Interviews conducted with customers led us to identify the following main issues, which are consistent with the challenges highlighted by farmers:

1. Difficulties in finding local producers and not knowing how to search for them were reported as major barriers to buying food directly from small farmers

   "I know a few, but they're far away. If they were nearby…" (C2)

2. Interviewees reported **preferring supermarkets** because of convenience and a wider selection of products

   “I don't go to the fair anymore because the supermarket offers all types of products, and it's all in the same place” (C2)

   "I normally do my shopping at the supermarket. I do go to the farmers market, but it’s only twice a month" (C1).

4.2 Concept resulting from ideation, iterations and refinements

The combination of exploratory research, brainstorming and iterative evaluations with users resulted in the DigiFarm concept, a blockchain-based digital marketplace targeting the needs of all the identified personas. In particular, the service aims at connecting farmers with potential customers (addressing issues 1, 2, 4, 5 and 7, described in 4.1) helping them sell products and surplus directly to customers (dealing with issues 1, 2, 5, possibly 6 and 8) in the physical context of the farm (which can support issues 1, 2 and 4).

The service takes the form of a multiplatform application available for web and mobile. Upon registration, farmers can list their products on sale. To take advantage of increased transparency and traceability offered by DLT, farmers can use the system also to optionally add information – manually or through automated systems based on technologies like NFC and IoT - about the products being offered (e.g., type of soil, fertilizers and pesticides used if any, and when the item was harvested). This feature was particularly appreciated by customers and, despite being time-consuming, deemed important by farmers. Also, we believe that this feature offers the opportunity for less tech-savvy farmers to get help from younger family members and ultimately foster their involvement in the family business.

Customers can search for local producers and buy goods conveniently through DigiFarm, without the need for going to farmers’ markets on specific days. Likewise, farmers do not need to leave the farm to sell their product. Through DigiFarm, producers can better manage their daily business activities by keeping track of the orders received. Indeed, once the order is placed, the farmer receives a notification via email or through the mobile app with the order details. Moreover, digital records of the orders received over time are permanently stored on the ledger and can be accessed by farmers to assess the business performance, as well as estimate future demand and adjust production accordingly. The customer is notified when an order is ready for pick-up. The information related to the products being purchased is then encoded in a QR code tag that can be printed and added to the basket, allowing customers to access food-information on demand.

User profiles - of both farmers and customers - are linked to a digital wallet that allows users to securely manage their transactions in the blockchain. Through smart contracts data is securely stored and made accessible to all users, while transactions are automatically performed and validated within the network, removing the need for financial intermediaries. As one of the main advantages of DLT is the reduction if not complete removal of transaction fees, the system was initially intended to allow for crypto-based payments only. Nonetheless, alternative digital payment methods (e.g., Multibanco) were added to the DigiFarm service after design iterations with users. In fact, participants of both CJ and EP sessions raised concerns about crypto-based payments. Customer EP1 reported not being accustomed to mobile and crypto payments, stating she would prefer to pay the farmer in cash upon

collecting the basket. Finally, farmers can enhance their DigiFarm profile by including optional information such as a description of their business (e.g., the farm's history), as well as share a calendar of the fairs they will attend, events organised at their farm (e.g., open days), job vacancies and special offers. We included such feature to help raise awareness on the agricultural sector and increase farmers visibility but decided to keep it 'optional' as it could be quite time-consuming. Interestingly, this was one of the most appreciated attributes of the system. Participants saw it as a means to bring producers and customers closer to each other by providing them with a space to bond and learn (CJ 3, CJ2 and EP1) and ultimately feel "part of a community" (CJ2 and EP2).

Although DLT is expected to completely remove the need for a central authority or third-party intervention, it doesn't eliminate the need for the 'human touch'. A relevant aspect that emerged from the design iterations is indeed the need to complement the digital service with human actors; intermediaries that facilitate onboarding and use of the app. As argued in the literature, the agricultural sector has never fully undergone a digital transformation (Tripoli & Schmidhuber, 2018). Small farmers, especially older ones, often lack the skills and resources to use and take full advantage of new technologies. In rural areas, some farmers still have neither a laptop nor a smartphone with an internet connection. Although the global digital agriculture market growth rate is already above 10% (Research and Markets, 2023), the need for a supporting structure providing human aid to digitally excluded users was clearly highlighted by both farmers and customers. Literature reports on several examples of organizational forms to facilitate the connection between small producers and consumers. Among them, we've identified the Direct-to-Consumer Food Hub (D2CFH) model (Matson et al., 2015, 2016) as the most appropriate for our purpose and therefore included such organizational structure as an integral part of the service. Food Hubs (FH) are "innovative organizational arrangements capable of bridging structural holes in the agri-food markets between small producers and the consumers" (Berti & Mulligan, 2016, p. 1). The concept of FH "has emerged as a logistical vehicle that facilitates a local food supply chain" (Matson & Thayer, 2013, p. 44). In the Direct-to-Consumer model, the FH works as an intermediary service provider to help connect farmers with final consumers. The D2CFH is usually "operated by a mix of staff and volunteer labor" that are responsible for services like distribution, which "is made directly to end consumers, with pick-up locations at customer residences, workplaces, or other designated sites" (Matson et al., 2016, p. 9). For the DigiFarm service to fully meet the needs of our target customers the active participation of additional facilitating stakeholders was key. Such facilitators would be responsible for (i) customer support in person and over the phone; (ii) helping with orders delivery for special cases; and (iii) supporting the farmers in using the service, inputting data, preparing the QR code content and generating the tags. The customer service of DigiFarm will be particularly relevant for non-tech-savvy or digitally excluded users as facilitators can manage the system on the farmers' behalf either upon need, or periodically, at scheduled intervals.

5. Discussion, conclusions and limitations

DLT has the potential to transform the agri-food sector, empowering rural and underserved farming communities by enabling the creation of a more environmentally sustainable and socio-economically inclusive food system. Several PoC and pilot projects are running all over the world to test this specific use case. However, the success rate of these initiatives is still limited. Here we argue that design can play a fundamental role in advancing research and practice on blockchain applications in the agri-food

sector. To provide evidence of the potential contribution of design to the sector, we've presented the scoping and ideation of DigiFarm, a blockchain-based service to support Portuguese small farmers.

Our findings only partially align with the claims made in the literature, which presents transparency, traceability, and financial benefits - such as reduced transaction costs and easy access to credit - as the main value propositions of DLT applications in the agri-food sector. Financial benefits related to the use of DLT for building digital identities or keeping track records to access credit didn't come up at all in the interviews with farmers, while the exclusive use of blockchain-based payment methods was referred to as a "limitation" (EP1). Our study indeed suggests that farmers (particularly the older ones) would still choose traditional payment methods over cryptocurrencies. This result is not surprising considering the lack of young farmers in the agricultural industry (in 2019 the average age of single holders in Portugal was 62 years (INE, 2020)). Despite the claims about cryptocurrencies being the future of money, we argue that a service targeting the 'current' agri-food system should allow for the use of multiple payment methods to ensure access to both tech-savvy and digitally excluded users. On the contrary, increased traceability and transparency were positively evaluated by participants in our study, both farmers (EP2) and customers (CJ2 and EP1). In particular, the possibility of discovering "the story behind a product" was described as exciting (CJ2). Although some participants (CJ3 and CJ1) raised concerns about the time required to input food production information, they could see the value of it. Interestingly, none of the participants reported being concerned about the risk of farmers providing misleading or fraudulent information. This could be explained by the deterrent effect of accountability. In fact, once added to the ledger, the data is publicly and permanently available, thereby facilitating the reporting of dishonest claims.

Probably the most interesting finding that emerged from our study is the need for developing services that facilitate interactions and relations between multiple actors within the community. Although disintermediation and automation are presented as the main strengths of DLT, relational/social aspects are still of prominent importance. Yet, only one of the existing projects analyzed – i.e., 1000EcoFarms - has the bolstering of the relationship between farmers and customers as one of the core elements of its value proposition. The creation of a communication channel that allows farmers and customers to find each other, exchange information, and ultimately learn from each other doesn't require the use of DLT; nonetheless, it emerged as a primary need from the empathizing phase. Throughout the entire evaluation process of DigiFarm, participants praised this feature of the service as it creates social bonds – "farmers are people with a story I can get to know about [...] I cannot have such connection with a supermarket" (CJ2) - and a sense of community (CJ2, CJ3, EP1, and EP2). Despite adding information about their business being time-demanding, farmers didn't regard it as an excessive burden, especially since the service allows them to customize the extent of the information to enter and the degree of interactions with customers (CJ1 and CJ3). Another relevant relational/social aspect that should be taken into account when envisioning a service to support small-farmer communities is the need to design a social/organizational structure around it that facilitates the connection between producers and consumers as well as their interactions with the technology. In this study, we have identified in the D2CFH model one such structure (Matson et al., 2016) as, by leveraging on social capital, it allows to produce common value that can then be taken back to the community (Nash & Briggs, 2020). Here we argue that promoting a systemic transition of the agri-food sector towards (social, environmental and economic) sustainability requires a deep understanding of the context. In such a scenario, adopting a design-driven approach can lead to an outcome that is much more than a technological solution. Rather, the outcome is an enabling system - i.e., products

or services meant “to enable individuals and/or communities to achieve a result, using their skills and abilities while regenerating the quality of the living contexts in which they happen to live” (Manzini, 2007, p. 240). As our study suggests, the introduction of technology in a context that relies on limited technology access, could increase inequalities and exacerbate the issues it's meant to solve. Therefore, to generate technology-enabled social innovation, we can not only design a technological solution without envisioning an organizing structure for the community that will use it. As pointed out by Nash and Briggs, producing positive change by means of technology in a resource-limited space “requires participation and freely given labour time of the community” (2020, p. 52); in other words, it requires social capital and consequently a system to administer it. As the community is at the same time the end-user and a resource, it is and must be thought of as part of the solution. The need for considering social capital in the design of the DigiFarm service (e.g., individuals serving as volunteering facilitators) emerged directly from participants in our study, thus emphasizing that the technology is only a piece of the system.

The UCD approach adopted in our study helped surface the limits of DLT within the specific social context of farming communities, raising further research questions and avenues for design to explore: e.g., how can designers promote adoption and understanding of DLT in the agri-food sector? How can we increase trust in DLT, fight misconceptions and increase awareness of the financial benefits the technology can bring? Those are pertinent questions for the design community to answer. Developing a sustainable and inclusive food supply chain entails a paradigm shift that goes beyond technological change to address how technology is socially constructed, thus implying the need to design DLT applications around and together with users. The current disconnect with people's needs that seems to characterize most of the DLT initiatives contrasts with the opportunity that such technology offers. Based on the results from our study, we argue that by adopting a user-centred perspective to technology-enabled innovation, design can help break the ‘hype cycle’ surrounding blockchain and ultimately ensure the development of solutions that are people-oriented rather than tech-centred.

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Acknowledgement: This work was supported by the European Commission under project BIG ERA Chair (grant agreement 952226). ITI/LARSyS is funded by FCT Project UIDB/50009/2020.