land

MDPI

Article

An Overview of Frontier Technologies for Land Tenure: How to Avoid the Hype and Focus on What Matters

Simon Hull [1,*], Harold Liversage [2], Maria Paola Rizzo [3] and Vladimir Evtimov [3]

[1] Division of Geomatics, University of Cape Town, Cape Town 7701, South Africa
[2] International Fund for Agricultural Development (IFAD), 00142 Rome, Italy
[3] Food and Agriculture Organization of the United Nations (FAO), 00153 Rome, Italy
* Correspondence: simon.hull@uct.ac.za; Tel.: +27-21-650-3574

Abstract: Secure land and natural resource rights are key ingredients for rural transformation, social inclusion, and the realization of the Sustainable Development Goals. In many cases, these rights are not formally recorded, and statutory land administration systems are inaccessible to rural communities. The rapid development of geospatial technologies and systems, combined with participatory methods for social empowerment, have contributed significantly to addressing these challenges and in developing fit-for-purpose land administration/land recordation systems that promote land tenure security, but with the plethora of options currently available, it is challenging to know which technologies are appropriate for what circumstances and purposes. This paper reports on the findings from a joint FAO/IFAD project that addresses this problem. Thirteen one-hour interviews were conducted with knowledgeable experts to showcase which technologies are being used for what purposes and by whom, the associated benefits and challenges, and what the future may hold. We conclude that technologies are best used in partnership with communities and as integrated solutions, that successful implementations must incorporate maintenance plans, and that the real challenge is not the technology–it is the social, legal, and political context. These findings are useful for governments, NGOs, academia, donors, and others involved in land-related projects aimed at benefitting small-scale farmers.

Keywords: frontier technology; land tenure security; land rights; land administration; fit-for-purpose

Citation: Hull, S.; Liversage, H.; Rizzo, M.P.; Evtimov, V. An Overview of Frontier Technologies for Land Tenure: How to Avoid the Hype and Focus on What Matters. *Land* **2022**, *11*, 1939. https://doi.org/10.3390/land11111939

Academic Editors: Dionissios Kalivas, Christos Chalkias, Thomas Alexandridis, Konstantinos X. Soulis and Emmanouil Psomiadis

Received: 11 October 2022
Accepted: 27 October 2022
Published: 31 October 2022

1. Introduction

IFAD (the International Fund for Agricultural Development) and FAO (the Food and Agriculture Organization of the United Nations) seek to improve the livelihoods of small-scale farmers and customary land rights holders through targeted investment projects. Many projects funded by such international finance institutes have few or no standalone land-tenure projects, but they touch upon tenure issues, especially in rural development. Examples include irrigation, improved natural resource management, rural infrastructure development, climate change adaptation, afforestation, and forest management. Tenure issues need to be assessed and, if necessary, addressed to:

- Achieve positive long-term impact for small-scale producers (e.g., by setting incentives to improve agricultural practices);
- Mitigate risks (e.g., exclusion of vulnerable groups, including women, increased inequality through elite capture, involuntary land expropriation, various types of conflict between communities, individuals, and land grab by companies).

Inadequately addressing tenure issues carries the risk of overlooking the needs of vulnerable groups or the project not being effective/sustainable [1]. In some cases, there is also the risk of conflict [2]. Improving land tenure security is hence an important component of these investment projects, and frontier technologies offer opportunities for improvements in this regard.

Secure land and natural resource rights are key ingredients for rural transformation, social inclusion, and the realization of many of the Sustainable Development Goals (SDGs), especially in the developing world. FAO and IFAD [3] identify SDGs 1, 2, 5, 11, and 15[1] as applying particularly to land-related targets with a focus on land access and tenure security. Many rural communities in the developing world access land and the associated natural resources through a diverse range of tenure regimes from across the land tenure continuum [4]. In many cases, these rights are not formally recorded or registered, and very often, statutory land administration systems are inaccessible to rural communities [5]. As a result, land transactions are often not formally recorded, people's ability to leverage finance through their proof of tenure security is restricted, and more fundamentally, their ability or incentives to invest in sustainable land management and land-based economic activities is undermined.

The rapid development of geospatial technologies and tools, combined with participatory methods for social empowerment, have contributed significantly to addressing these challenges [3]. Spatially enabled land administration can form the basis for improved tenure security and provide improved services and information for a variety of uses, from land management and planning to environmental monitoring and climate action [6]. Frontier technologies create opportunities and potential benefits in the development of affordable and accessible fit-for-purpose land administration systems.

There are, however, various challenges and risks associated with the use of frontier technologies. One of these is the hype that often accompanies new technologies, creating expectations that may not be met [7,8]. Another is the empowerment of rural communities through the use of technologies. Without regulatory oversight to ensure the security of data and protection of privacy, technology can foster exclusion, authoritarianism, and social control rather than inclusion and empowerment [8]. For practitioners involved in land-related agricultural investments targeting small-scale farmers on customary land, it may be difficult to know what technologies are appropriate for which situations and how to apply them while upholding the 'do no harm' principle [9].

In this paper, we explore how frontier technologies can be used to improve land tenure security, taking the above into consideration. The aim of this paper is hence to review, in broad terms, the experiences of knowledgeable experts who have been using frontier technologies for land tenure security, with a particular focus on avoiding the hype surrounding some frontier technologies while drawing attention to the things that matter most[2]. The motivation behind the paper is to provide investment organizations (such as the World Bank, USAID, FAO, and IFAD), non-governmental organizations (NGOs), governments, academia, and others involved in land-related projects that seek to improve the livelihood of the rural poor, with guidelines for the use and adoption of new technologies and opportunities, based on the first-hand experiences of those with established track-records. This paper begins with some definitions of key terms and a description of the methodology used before drawing together the results of the analysis.

2. Definitions

In the land administration/governance/tenure domain, there are several terms that are sometimes used loosely or interchangeably. At the outset, it is hence important to ensure that these terms are commonly understood for the purposes of this paper.

Land tenure has been variously defined as:

- "the terms and conditions on which land is held, used and transacted" [10], or
- "the relationship, whether legally or customarily defined, among people, as individuals or groups, with respect to land" [11], or
- "the rules, authorities, institutions, rights, and norms that govern access to and control over land and related resources . . . It governs who can use what resources, for how long, and under what conditions" [12].

Land rights, broadly speaking, refer to *who can do what* with land (e.g., cultivation, grazing, occupation, traversing, accessing water, bequeathment, transaction, exclusion),

while **land tenure** refers to *how those rights are held* (e.g., following local customs and norms, with certification by a recognized community authority such as chief or slumlord, or by official deed or title) [13].

Many publications refer to **tenure rights** in the context of rights of use, occupation, or ownership of land. For example, Larson and Springer [14] refer to tenure rights as determinants of "who is allowed to use which resources, in what way, for how long and under what conditions, as well as who is entitled to transfer rights to others and how", including "rights to access, use, manage, exclude others from, and alienate land and resources." This relates to our definition of *land rights* given above. FAO [2] refers to tenure rights as "the principle way in which people, the resources and the conditions of use are connected." The *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security*, or VGGTs [15], refer to 'tenure rights' over 200 times but fail to provide a definition for the term. However, they define **tenure systems** as the mechanism by which societies regulate access to land, fisheries, and forests. "These tenure systems determine who can use which resources, for how long, and under what conditions. The systems may be based on written policies and laws, as well as on unwritten customs and practices" [15]. Tenure systems are best understood, then, as systems that connect land rights and land tenure.

Thus, to avoid confusion while following accepted norms, for the purposes of this project:

- *Land rights* are defined as the rights held by people or communities over land, including rights of access, occupation, and resource use, as well as the right to transfer those rights to others and exclude others from exercising those rights over the land in'question.
- *Land tenure* refers to the way in which land rights are held and recognized (whether through written policies and laws or unwritten customs and practices), including the associated terms and conditions.

Weinberg [16] notes that **land tenure security** is "the legal and practical ability to defend one's ownership, occupation, use of and access to land from interference by others". Such challenges often come in the form of investment projects such as agri-businesses, mining ventures, wind farms, and irrigation projects, or they may stem from increased urbanization, population pressure, and climate change. Without secure tenure, customary land rights-holders are easily displaced by powerful elites see, e.g., [17]. Land tenure security reflects the *meaning* that people and societies place on land rights [18], and measures of tenure security are strongly influenced by people's *perception* [18,19].

IFAD [12] identifies three main characteristics of land tenure security:

- Duration—how long different land rights last.
- Protection—whether land rights are upheld when challenged.
- Robustness—whether land rights-holders can use and dispose of their land rights without interference.

Poor rural communities in the developing world are IFAD's and FAO's principal target groups. It is important to identify the defining characteristics of such groups of people because references are made in the literature to apparently synonymous yet quite distinct terminology. Cousins [20] notes that the terms 'customary', 'communal', and 'traditional' are often and incorrectly used as synonyms. 'Indigenous' and 'tribal' may be added to that list. He asserts that it is important that these terms be understood as distinct.

Customary land rights-holders are those who hold rights to land under **customary tenure** wherein landholding is "regulated by local traditional institutions, based on customary norms and practices" [17], and access to land is via "social norms and networks . . . where local powers play an important role in land rights regulation and conflicts resolution" [21]. Customary tenure may be divided into the 'holding' and the 'commons' [10]. The 'holding' refers to land occupied and used exclusively by individuals or households for residential, farming, or other activities. The 'commons' is land shared by multiple users for grazing and gathering. Access to the commons may either be open or limited to

certain group members. While providing *de facto* tenure security, these use rights do not confer individual ownership and may be subject to arbitrary deprivation at the hands of corrupt traditional leaders [11,22–24]. The following general characteristics of customary land tenure systems are noted [17,24–26]:

1. Land rights are socially embedded, overlapping, and nested. They mirror the social and cultural *values* of the community and gain legitimacy from the *trust* a community places in the institutions governing the system.
2. Rights are derived from accepted *membership* of a social unit (kinship ties) either through birth or acquired allegiance.
3. They allow *multiple uses* (e.g., farming, fishing, occupation) and *users* (e.g., farmers, migrants, herders, residents) of resources.
4. Rights are both individual (the holding) and communal (the commons).
5. They are *dynamic* and *evolve* in response to external or internal change. Boundaries are flexible and negotiable.

For the purposes of this report, the intended beneficiaries of land tenure security improvement programs are **small-scale farmers** living and working on land under conditions of customary tenure. Small-scale farmers are not a homogenous group [27,28]. They are defined by their context and their characteristics, both of which vary widely. Generally, it is accepted that 'small-scale/smallholder farmers' are those farming on 2,0 ha or less, though this is a rough measure given the different potential of land vis. soil quality and rainfall [29]. "Overall, smallholder farmers are characterized by marginalization, in terms of accessibility, resources, information, technology, capital and assets" [27]. Woodhill, Hasnain, and Griffith [28] note the following:

1. The livelihoods of over a third of the world's population depend on small-scale agriculture;
2. Small-scale farmers produce a significant proportion of food consumed in developing countries;
3. Many small-scale farmers live close to or below the poverty line, and most aspire for a better future for their children.

Frontier technologies offer the potential to combat current global challenges, such as poverty and climate change, while disrupting and displacing existing processes [30]. Manyika et al. [7] refer to such technologies as having "the potential to disrupt the status quo, alter the way people live and work, rearrange value pools, and lead to entirely new products and services." Such technologies have the potential to assist in the global drive for sustainable development, with the caveat that they also have the potential to widen existing inequalities or create new ones as technologies may be quickly adopted by some, leaving others behind [8].

Ramalingam et al. [30] identify five characteristics of frontier technologies:

1. They can address large-scale economic, social, or political opportunities or problems;
2. They are characterized by rapid technological development;
3. They have the potential for broad impact across diverse fields;
4. They have the potential for displacing existing technologies and bypassing expected technological pathways;
5. They involve considerable uncertainty, largely due to their adoption outstripping regulators' and policymakers' ability to set standards for their use [31].

Typical examples of frontier technologies include (but are not limited to): artificial intelligence (AI), machine learning, distributed ledger technology (DLT, such as blockchain), 'drones' (or Unmanned Aerial Vehicles–UAVs), satellite-based imaging sensors (generally referred to as 'remote sensing' or 'Earth observation'), the Internet of Things (IoT), big data, Global Navigation Satellite Systems (GNSS, such as the Global Positioning System, GPS), and mobile device/smartphone applications. This paper will briefly relate these technologies to opportunities for improving land tenure security and inclusiveness in developing contexts.

In the context of frontier technologies and their impact on land administration processes and land tenure security, many innovations are aimed at 'going digital'. To understand what this means, it is necessary to distinguish between three distinct terms that are often, and incorrectly, used interchangeably: digitization, digitalization, and digital transformation. According to Gupta [32], Hapon [33], and Asite [34]:

- **Digitization** is the creation of a digital copy of an analog or physical object or attribute, i.e., converting something that is not digital into a digital representation or artifact.
- **Digitalization** cannot occur without digitization. It is the use of digitized information to improve business processes. Examples include collaborating on documents shared online. This increases productivity and reduces costs by enhancing access to digital data and processes.
- **Digital transformation** involves an organizational change to leverage the opportunities made possible by digitization and digitalization. It requires a rethink of the way things have been conducted in the past, taking advantage of the possibilities afforded by new technologies to radically increase productivity and creativity.

These phases of 'going digital' loosely correspond to the Land Information System (LIS) generations identified by Bennet, Pickering, and Sargent [35]. Generation 0 LIS is identified as the pre-digital phase of paper-based systems, with Information Technology (IT) possibly playing a supportive role. Generation 1 LIS corresponds loosely with digitization: standard data collection tools and processes are still used, but some data and analysis are occurring digitally. Generation 2 LIS corresponds loosely with digitalization: the creation of tools that utilize alternative/frontier technologies to expand the range of definable land interests. Digital transformation occurs when Generation 3 LIS emerges, and entrepreneurial approaches disrupt conventional methods of land information management. The disruptive and opportunistic nature of frontier technologies allows organizations to leapfrog generations by-passing established technologies that may be more expensive, less efficient, or of inferior quality [30]. This is a considerable opportunity for less-developed contexts to accelerate development.

3. Materials and Methods

This project takes a grounded theorizing approach [36] to the analysis of qualitative data (mostly interviews). The research team comprised of an external consultant and two members each of the land tenure teams at FAO and IFAD. The team conducted interviews with 13[3] 'knowledgeable experts' to learn from them which technologies they are using for land tenure projects and what their experiences have been. We chose people and organizations with established track records of innovation (research and development) and application of such technologies. Sampling was hence purposive in that the research team identified suitable experts based on our own extensive experiences in the field of land tenure and administration. Some experts also provided us with relevant literature to support the content shared via interview, and this was incorporated into the data.

Each hour-long interview was conducted online in English from May to June 2022 and was recorded with the consent of the interviewees. Six interviewees were female, and nine were male (in two cases, a man and a woman were interviewed together). Interviewees were drawn from a broad base of expertise, including representatives from academia, international organizations, and solutions providers.

- International organizations included groups such as the International Federation of Surveyors (FIG), FAO, World Bank, USAID, and Ordnance Survey International.
- Solutions providers are companies/organizations that offer a tool or platform for land administration/land rights recording. We interviewed representatives from Cadasta, Meridia, Medici Land Governance, and Terra Firma.
- Academics were interviewed from the Universities of Twente (Netherlands), Münster (Germany), Zagreb (Croatia), and Swinburne (Australia).

It is important to note that these distinctions are blurred: several interviewees wore multiple hats (e.g., academics engaged in private consultancy and sitting on boards or committees of international organizations), and several interviewees have moved between different roles and reported on their experiences broadly. Overall, four interviewees represented academia, four represented solutions providers, and seven represented international organizations. For the full list of interviewees, see Table A2. Interviewees drew from their experiences in 55 countries, from Tonga and Samoa in the Pacific, through Africa and Europe to Oceania. Much work is currently being conducted in east Africa, and this is reflected in the descriptions below, but these insights are not intended to pertain only to this region.

The interviews were transcribed and shared with the interviewees for verification that their contributions had been faithfully recorded. Transcription and editing involve some interpretation on behalf of the researcher, which is why it is important that the transcriptions are shared with interviewees for verification before proceeding to analysis. Interviewees were also afforded the opportunity to make corrections or elaborations as they deemed appropriate.

The full list of questions (see Table A1) was shared with the interviewees before the interviews but note that these were used as a guide only, and the emphasis in each interview was on creating a *conversation* around frontier technologies for land tenure. The most commonly asked questions related to:

- Understanding interviewees' interest and involvement in land tenure projects;
- Their experiences with frontier technologies;
- Their biggest challenges and successes;
- Where they see the future for land rights mapping.

The transcribed interviews and shared publications were reviewed using Atlas.ti version 8 computer-assisted qualitative data analysis software (CAQDAS). This involved open coding of the qualitative dataset [37], focusing on identifying the different types of frontier technologies used, the purposes for which they are used, the different approaches adopted, and the associated benefits and challenges. This yielded an initial list of over 120 codes and a high level of saturation[4] for the dataset. These were then reviewed and refined, merging codes that relate to the same/similar concepts or recoding datasets to include previously overlooked concepts, following the spiral nature of grounded theory analysis [38]. In this way, the total number of codes was reduced to 90. Such abstraction of qualitative datasets is useful for reducing complexity and allowing relevant themes to emerge. In the following section, the findings from this qualitative data analysis exercise are presented.

4. Results

The subtitle of this paper is 'how to avoid the hype and focus on what matters'–these were two prominent themes that emerged from the data: hype (or expectation vs. reality) and focusing on what really matters (or 'it's not about the tech'). It was clear from the interviews and reviewed texts that some service providers—not including those interviewed—have over-promised what their technologies can do, leading to disillusionment and disappointment, while some users have had inflated expectations, viewing technology as a 'magic bullet' that can solve their problems. This has fostered a tendency to focus on technology, losing sight of some of the highly important, non-technological issues that should first be addressed. In this section, the results are presented, beginning with 'what really matters' and ending with the 'hype'.

4.1. Identifying What Really Matters

Land is a sensitive topic both politically and socially. It requires more than a technological focus to address land tenure issues. One interviewee noted that the big problems today are not spatial or technical. This is not to say that technical innovation around land rights mapping has peaked because new innovations are still being developed. Such technical

challenges will keep researchers occupied both now and in the near future. Rather, it was suggested that the big problems facing land tenure projects today are legal, social, and administrative. There should be a holistic approach addressing social needs, capacity development, and the political and legal environment. Another interviewee proposed that the focus should be on enabling beneficiaries and stakeholders around technology to address their context-specific needs in ways that are understood by beneficiaries. A third interviewee, referring specifically to land tenure projects in Africa, noted the following:

> "*Before talking about any large-scale land tenure project, countries in Africa need to have policies in place. Then that land policy needs to go hand in hand with policies allowing the use of tech. Tech is not a solution, it is an enabler. It enables people to do well what they intend to do. But if there is no intention/political will, tech doesn't mean anything. You will get frustrated with good gadgets and applications, but at the end you can't produce a result because the law won't support it or there will be too much red tape to get a result.*"

They identified four non-technical challenges to be addressed before embarking on any land-related projects:

1. **Political will**: Land is a sensitive topic, especially in post-colonial contexts. Political support is identified as a crucial enabler for success.
2. **Legal and policy frameworks**: A sound, supportive, and enabling land policy is necessary but not sufficient for success. The legal and political framework must extend to the use of information and communication technology (ICT) as well.
3. **Acceptance and adoption**: Land administration professionals can be slow to accept and adopt new technologies and procedures. Lack of capacity may hinder technological uptake.
4. **Customary land**: For tenure security on customary land, projects should adapt to customary norms. This means getting buy-in from the chiefs as well as the land rights-holders.

These points are discussed below, beginning with points one and two, which are presented together as the legal and political environment.

4.1.1. Legal and Political Environment

Technological solutions will not solve administrative, policy, and legislative shortcomings, nor can they combat a restrictive political environment. Hence, land titling projects must begin with policy development and institutional reform. Provided sensible policies and regulations are in place and applied, then technology is not a problem, but without these, "everything gets complicated!" said one interviewee.

Several interviewees commented on their experience with trying to use UAVs for land rights mapping in the its4land project [39]. In one case, there was a legislative void. In another case, there was over-restrictive legislation. In another case, policy and legislation were in place, but these were misaligned with the realities on the ground. In each case, the use of frontier technology for securing land tenure was hampered by an inadequate legal environment. An enabling policy and legal framework must form the foundation for land rights mapping; hence, one interviewee said, "Before you start, before you choose any tech, see if there is a law or policy in place supporting what you want to do, then political will."

As a means of creating such an enabling environment, Stöcker et al. [40] advocate for a combined bottom-up and top-down approach. The bottom-up approach is where solutions providers convince the government that the technology and processes are feasible and desirable for land rights mapping. This could be through pilot projects, workshops, or demonstrations. An interviewee noted that this approach was crucial for the successful use of USAID's Mobile Application to Secure Tenure (MAST) in Tanzania. Through a slow process of relationship building and garnering trust from the relevant government authorities, they were able to partner with the government in developing a procedure for securing land rights using GNSS-enabled mobile devices. The top-down approach of enabling laws and policies followed. They needed a minimum viable product to show the

relevant authorities, but it was the relationship and trust that had been built up over time that encouraged government buy-in.

Legislation may need to be amended to allow for new technologies and approaches. Such was the challenge for many countries in the 1990s when survey-grade GNSS became available and saw increased use in cadastral surveys. Land survey laws, some of which had been in place for half a century or more, needed to be amended to allow the use of this new technology (for example, in South Africa, the Land Survey Law of 1927 was renewed in 1997 to address this, among other concerns). In the interests of digital transformation, new technologies should be allowed to influence policy and legislation to avoid a situation of replicating outdated systems and processes digitally.

One area where this is playing out is that of digital identifiers. One interviewee said that the digital resolution of party transactions is "a key enabler going forward. Without being able to identify people properly and securely, you're still going to have a slower and potentially more manual and cumbersome process." Solutions providers such as Meridia are using digital signatures and fingerprints to secure transactions, whereas Terra Firma in Mozambique opted for facial recognition software to support party identification to avoid people handling devices in the covid-era. Legislative change is needed to support such moves away from wet signatures and to reduce/remove the need for paper-based services. These are some of the challenges being addressed in Armenia, according to an interviewee.

4.1.2. Acceptance and Adoption

There is a tendency in land authorities to avoid change, particularly when it comes to new technologies [35]. This restricts the potential for innovation and new service offerings. As noted above regarding the adoption of MAST in Tanzania, people take time to understand and trust new technologies. Shifting mindsets can take several years. As one interviewee said:

> "*As much as we want to run towards the frontier technologies and be at the cutting edge and the start of the diffusion curve, the reality is most of us, and most agencies, are still some way back behind the cutting edge. Diffusion doesn't happen at the flick of a switch. It's a process that takes any organization a long time*."

Others resist new approaches because they think these will replace them and they will lose their jobs [40]. In such cases, people need to be shown how new technologies can help them to become leaders and managers in their field. In one instance, however, an interviewee reported that they decided against the use of UAV-based mapping and automated feature extraction (AFE) precisely because it threatened jobs and replaced experiential opportunities for students and junior staff.

Another way of promoting acceptance and adoption of new technologies and approaches is to involve beneficiaries in the data collection process. One interviewee noted that "Participatory mapping is a very low cost and easy to use approach to gather information from citizens." Another interviewee promoted the use of 'trusted intermediaries' as data collectors. These were mostly youth from the villages who were trained in the use of technology (in this case, the MAST app installed on smartphones). Similarly, developers of the Solution for Open Land Administration (SOLA) ensured that the tools they designed were accessible and easy for community members to use. The beneficiaries themselves know the local context, languages, and customs and can help to ensure that processes are accessible to all. They have the trust of the community, so it is important to collaborate and build in community validation processes to gain acceptance and adoption.

Lack of capacity is another factor hindering acceptance and adoption of new technologies. One interviewee said that this includes financial as well as technical capacity. He stressed that governments must have the financial capacity to sustain projects once the donors have left, or else the project will 'die'. Similarly, donors often bring technical assistance with them to get projects going, but if this technical know-how leaves when the donors leave, the project will 'die'. Another common challenge is that, even if locals are trained in the use of new technologies, they take their skills to more lucrative jobs

elsewhere. Thus, Cadasta and the SmartLandMaps project both adopt a train-the-trainers approach to ensure that technical know-how remains where it is needed. Cadasta focuses on training government officials and other partners working on a project and getting them to train community members "so that there's a whole cascading training and capacity-building process".

4.1.3. Mapping Customary Land Rights

When we consider land tenure projects on customary land, there is a strong belief that land is best held in discrete, individualized ownership secured by a land title, whereas the reality might be much more complex and interesting [41]. One interviewee proposed that individualized titling serves to "dismember all of those parcels from the broader community holding . . . locking people into a national system that is fundamentally dysfunctional and inaccessible." Individualized titling is only one option, and there should be consideration of the full range of options available for securing land tenure [42]. Land titling projects involving customary land rights will challenge, and be challenged by, existing customs and norms [43].

The approach behind SOLA—combining a participatory methodology with geo-technologies—serves to find a suitable solution for communities that want recognition and protection of their land rights. Similarly, SmartSkeMa seeks to model existing land tenure concepts as closely as possible [44]. It is not only the spatial aspects that need to be mapped, but tool developers should consider how to map the social and legal aspects as well. Hence, the SmartSkeMa approach attempts:

> " . . . *to support both the legibility of customary land tenure to government authorities and the preservation of the customs within which tenure relations operate. Preserving customary rights to land requires also preserving customary ways of allotting, negotiating, and exercising those rights. Otherwise, the entire notion of customary land tenure itself becomes a shell or a cover for replacing customary tenure.*" [44]

When it comes to mapping customary land rights, people can be suspicious of new technologies and approaches, being fearful that they will be used to appropriate their lands [45]. Chiefs may see a land tenure project as an attempt to divest them of land and hand it over to individuals—who are no longer obeisant to their chiefdom—or to the government. In Malawi, Medici Land Governance addressed this challenge by first mapping the extent of the chiefdom areas. Using satellite imagery, chiefs were able to settle disputes between their territories. This demonstrated the usefulness of the technology. Next, the same process was used to map out family holdings within chiefdoms, and certificates were issued that linked families and individuals to the chiefdoms. Hence, it is important to understand cultural norms and make every effort to accommodate them before embarking on systematic land titling [43]. The following two quotations by interviewees support this point:

> "*We have to tread very carefully so that we don't also have problems with the norms in the community. You can't impose a new normal on the community with your titling, because that will break the community norms and create a new problem that wasn't there.*"

> "*I've seen too many projects led by Western consultants go completely wrong because people are dropping in with no context, no knowledge, trampling over the existing systems and imposing their approach, and it's either rejected outright or as soon as they leave, everyone goes back to doing what they had been doing before. I'm a big believer in locally led solutions. And it takes more time, sure, up front, but it definitely pays off.*"

4.2. Avoiding the Hype

Frontier technologies are disruptors of the status quo. They provide new opportunities for exploring alternate avenues to getting a job done, but it is cautioned that digitization of existing processes does not solve existing problems. One interviewee noted that "If it's a paper mess, with digital technology it will create a digital mess", highlighting the need to

move from digitization of 'paper messes' to digital transformation, leveraging the power of frontier technologies to transform processes and clean up the 'mess'.

There is merit in exploring frontier technologies simply to find out what they can do in a given situation: for example, how can UAVs [40] or blockchain [35] improve the process of recording customary land rights? However, there is a tension between exploring new opportunities vs. applying the newest technologies in appropriate contexts. It is important to understand the underlying problem and apply appropriate technological solutions. An interviewee had the following to say on this topic:

> "*In some cases, organizations want to apply the latest, new technology to solve a problem that doesn't really exist, that could be solved more easily. I really advocate for looking at the problem and needs of a land tenure situation first, and then checking out which technology could help to solve this problem and can this technology be maintained in a country context*."

Other interviewees cautioned against the tendency of some solutions providers to over-sell their products:

> "*Beware the hype surrounding what is promised vs. what is actually delivered. There must be the institutional and technological foundation to support the tech. Make sure you listen to the right advice from the right people–people who know what they're talking about and aren't just pushing a product*."

Blockchain is a good example of a potentially over-hyped product [35,46]. It came under some criticism from interviewees for being promoted as a 'magic bullet' solution/panacea to problems such as corruption and slow, bureaucratic land administration processes. One interviewee described it as nothing more than "syntactic sugar that supports elements of the financial transaction or smart contract." The following are cautions interviewees raised around the use of blockchain in land administration:

1. Blockchain does not improve the data. If the data in the land administration system are incorrect, applying blockchain will not correct the data; it will simply secure the incorrect data into the blockchain.
2. Blockchain does not offer anything that a classical, centralized, relational database would not be able to offer to land administration. "You can achieve the goals to have the good land administration system without blockchain, using the existing technologies for data management and information systems".
3. Land administration, and particularly land registration, deals with spatial objects (the land parcel), whereas blockchain does not deal with spatial information.
4. One of the advantages of blockchain is its immutability, yet land registration data are very dynamic.
5. Land administration is, in most jurisdictions, a state-sanctioned activity. Blockchain challenges the sovereignty of land registry data by taking it out of the public domain.

Blockchain has some advantages for land administration. One interviewee said, "I think what we're seeing is the confusion between using blockchain for *everything* rather than what it might be fit for purpose." It can be useful for dealing with financial settlements for conveyancing–Medici Land Governance are using it for paperless land transactions in Rwanda [47]. It can assist in finding a means of providing people with unique identification, and it can help to reward individuals and communities for making positive changes, such as engaging in sustainable agricultural practices or reforestation. Terra Firma is investigating such applications of blockchain in Mozambique. Cadasta is also investigating the use of blockchain technology to ensure that individuals and communities are benefitting from carbon credits being sold off their land and to secure their land tenure.

Innovations need to fit the context in which they are applied and should be appropriate for the need being addressed, i.e., they should be fit-for-purpose [39,48]. For Terra Firma in Mozambique, in one case, this meant eschewing digital solutions in favor of printed A3 maps. The expense of printing was offset by improved participation and inclusion by land rights holders and communities. "Being able to get people engaged in discussions,

being able to see and engage with maps and the location of boundaries and resources and conflicts was just that much better when you're dealing with a printed A3 map rather than a small piece of real estate on the screen that you can't see because it's too sunny." Thus, it is always important to review the hype surrounding technologies (in this case, high-resolution satellite images and mobile devices) in terms of their practicality in a given context.

Most solutions providers create open-source, tailor-made solutions that are adapted to local circumstances and needs. For SOLA, this means using an open-source platform that can be adaptable to any legal framework for both systematic and sporadic registration activities. "The intention has been to help low-income countries embark on the pathway of automation and digitization of land registration and cadastre processes, customizable for country contexts." The success of this approach is evident in SOLA's use and customization in countries from Guatemala and Cambodia to Sierra Leone and Angola and Nepal and Myanmar (to name a few). Others, such as Cadasta, use a proprietary software platform. They noted that technology is constantly changing and proprietary solutions "have a vested interest in staying on top of these changes, leaving us able to focus on community level support, building capacity, inclusivity, etc. So really our time and energy is way less about the technology and way more about how we enable local stakeholders around technology." The success of this approach is also evident by its adoption in countries across South America, Africa, Asia, and Oceania.

Avoiding the hype means re-evaluating assumptions around technology, such as adopting open-source or proprietary solutions, mobile devices or printed maps, UAVs, or blockchain. It means resisting the urge to adopt the next best thing and evaluating potential solutions for their merits in terms of project objectives. It also means listening to trusted voices who have conducted the hard work of testing products through pilots and applying appropriate solutions for the given context.

> "*We always start with the needs and adapt the suggestions and solutions to the country needs, the country requirements. There is really no one solution working for everybody. Establishing needs requires a dedicated team of consultants working in country. We also need to assess technical readiness and openness to new approaches*."

5. Discussion and Conclusions

In this paper, we set out to review the use of several frontier technologies for securing land tenure. New and innovative technologies and approaches offer new opportunities as well as fresh challenges. Organizations wanting to utilize these technologies and embrace the opportunities on offer should be forewarned to overcome the challenges and avoid potential pitfalls. New technologies and methods are being developed all the time; hence we have not intentionally focused on any specific technologies. Instead, we have drawn out over-arching principles that should remain relevant for several years to come. To this end, this paper focuses predominately on interviews with knowledgeable experts, supported by appropriate literature, to glean valuable lessons around the use of frontier technologies for securing land tenure, with a focus on how to avoid the hype and identify what matters most. Using a grounded theorizing approach supported by CAQDAS, the qualitative data were abstracted into codes, which were, in turn, categorized into themes. For the purposes of this paper, we focused on themes related to foundational principles ('what really matters') and hype.

We found that frontier technologies cannot solve all problems, and implementers and administrators need to exercise caution. Expectation is not always supported by reality. It is important to acknowledge the legal and political framework and garner the support of the relevant authorities and stakeholders. An enabling political, technical, financial, and legal environment is required. It is also important to adopt an integrated approach that draws together the relevant land rights holders and other stakeholders as partners in the land rights mapping process. Leveraging the support of people on the ground is a key enabler for success. So, too, is the need to build in capacity development for sustainability.

Many land tenure projects involve people living under conditions of customary land tenure. Such contexts require focused attention because there is no one-size-fits-all approach. Solutions must be tailored to fit the local circumstances in ways that will be understood and accepted by the would-be beneficiaries. The temptation to apply solutions that have worked before, in other contexts, must be avoided. Adopting such a sensitive approach to development, guided by the principle of 'do no harm', will support the realization of SDGs 1, 2, 5, 11, and 15.

Frontier technologies provide the opportunity for tailor-made, adaptable solutions to address context-specific needs through accepted processes while allowing societies to leapfrog some of the steps on the way to the digital transformation of land administration processes, but an enabling environment must be in place for this to happen. It is of little use if the latest technologies are adopted while governments, beneficiaries, and other stakeholders do not have the capacity to use them—and keep on doing so.

Author Contributions: Conceptualization, H.L., M.P.R. and V.E.; Formal analysis, S.H.; Funding acquisition, H.L.; Investigation, S.H.; Methodology, S.H.; Project administration, H.L., M.P.R. and V.E.; Software, S.H.; Writing—original draft, S.H.; Writing—review and editing, S.H., H.L., M.P.R. and V.E. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the International Fund for Agricultural Development and the Food and Agriculture Organization of the United Nations, contract number 72390-0001. The APC was funded by the University of Cape Town.

Data Availability Statement: Due to the sensitive nature of interview data, access to raw transcripts is not provided.

Acknowledgments: The authors acknowledge the contributions of the peer reviewers and thank them for their thorough reviews. The authors are also grateful to each of the interviewees who, without exception, enthusiastically engaged with us on this project. Their time, expertise, and insight are much appreciated. Finally, we are indebted to Oliver Mundy for his administrative support in setting up the interviews, managing resources, and offering helpful insights along the way.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Appendix A

Table A1. Interview questions.

What has been your involvement in land tenure/land rights-related projects?
Where does your interest in this line of work/research come from, and how long have you been doing it?
What is your understanding of 'Frontier Technologies'?
Please describe your experience of using any of these, or similar, technologies for mapping land rights?
What have been the biggest challenges you have encountered in this regard?
What have been the biggest successes you have experienced in this regard?
What are the challenges and risks associated with land tenure security projects?
Based on your experiences, what advice would you give to an organization embarking on a land rights mapping/land tenure security project?
Who do you think are the leaders/innovators in this field?
In your opinion, where do you see the future for land rights mapping?

Table A2. List of interviewees.

Name	Organization
Anthony Beck	Ordnance Survey
Keith Bell	Independent consultant
Rohan Bennett	FIG/Swinburne University of Technology
Mykhailo Cheremshynskyi	Independent consultant
Amy Coughenour-Betancourt	Cadasta
Vladimir Evtimov	FAO
Zdravko Galić	University of Zagreb
Mila Koeva	ITC (University of Twente)
JP Molina	Cadasta
Simon Norfolk	TerraFirma
Yuliya Panfil	New American
Maria Paola Rizzo	FAO
Didier Sagashaya	Medici Land Governance
Claudia Stöcker	SmartLandMaps/University of Münster
Olivier Vernin	Meridia

Notes

[1] Goal 1: end poverty in all its forms everywhere; Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture; Goal 5: Achieve gender equality and empower all women and girls; Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable; Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. (www.sdgs.un.org accessed on 27 October 2022)

[2] This paper is part of a larger FAO and IFAD project investigating frontier technologies for tenure—publication forthcoming. In this paper we are focusing on a subset of the data with particular interest in these two questions: how to avoid the hype and focus on what matters most.

[3] We sent out fourteen invitations in total; only one declined.

[4] Saturation occurs when the researcher finds no new codes emerging from the dataset [37].

References

1. Higgins, D.; Balint, T.; Liversage, H.; Winters, P. Investigating the impacts of increased rural land tenure security: A systematic review of the evidence. *J. Rural Stud.* **2018**, *61*, 34–62. [CrossRef]
2. FAO. Creating a system to record tenure rights and first registration. In *Governance of Tenure Technical Guide 9*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2017; ISBN 9789251098349.
3. FAO & IFAD. *GeoTech4Tenure—Technical Guide on Combining Geospatial Technology and Participatory Methods for Securing Tenure Rights*; FAO: Rome, Italy, 2022; ISBN 9789251366714.
4. UN-HABITAT. *Property Theory, Metaphors and The Continuum of Land Rights*; Victoria, Q., Ed.; UNON, Publishing Services: Nairobi, Kenya, 2015.
5. Hornby, D.; Royston, L.; Kingwill, R.; Cousins, B. Introduction: Tenure practices, concepts and theories in South Africa. In *Untitled: Securing Land Tenure in Urban and Rural South Africa*; Hornby, D., Kingwill, R., Royston, L., Cousins, B., Eds.; University of KwaZulu-Natal Press: Pietermaritzburg, South Africa, 2017; pp. 1–43.
6. Stanley, V.; Törhönen, M.-P. Towards Spatially Enabled Land Administration, Improving Systematic Registration. In Proceedings of the Annual World Bank Conference on Land and Poverty, Washington, DC, USA, 8–11 April 2013; The World Bank: Washington, DC, USA, 2013; pp. 1–20.
7. Manyika, J.; Chui, M.; Bughin, J.; Dobbs, R.; Bisson, P.; Marrs, A. *Disruptive Technologies: Advances that Will Transform Life, Business, and the Global Economy*; McKinsey Global Institute: San Francisco, CA, USA, 2013.
8. UNCTAD/TIR. *Technology and Innovation Report 2021: Catching Technological Waves/Innovation with Equity*; United Nations Publications: New York, NY, USA, 2021; ISBN 9789211130126.
9. OECD. *Do No Harm: International Support for Statebuilding*; Organisation for Economic Co-Operation and Development (OECD): Paris, France, 2010; ISBN 9789264046245.
10. Adams, M.; Sibanda, S.; Turner, S. Land tenure reform and rural livelihoods in southern Africa. *Nat. Resour. Perspect.* **1999**, 1–15.
11. FAO. *Land Tenure and Rural Development*; Food and Agriculture Organisation of the United Nations (FAO): Rome, Italy, 2002; ISBN 9251048460.
12. IFAD. *Improving Access to Land and Tenure Security*; International Fund for Agricultural Development: Rome, Italy, 2008.
13. Fisher, R.; Whittal, J. *Cadastre: Principles and Practice*; Roger Fisher, Jennifer Whittal and the South African Geomatics Institute: Cape Town, South Africa, 2020; ISBN 978-0-620-82878-9.

14. Larson, A.M.; Springer, J. *Recognition and Respect for Tenure Rights*; NRGF Conceptual Paper: Gland, Switzerland, 2016.
15. FAO. *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security*; Food and Agriculture Organisation of the United Nations: Rome, Italy, 2012; ISBN 978-92-5-107277-6.
16. Weinberg, T. *Rural Status Report 3: The Contested Status of 'Communal Land Tenure' in South Africa*; Sparg, L., Ed.; Institute for Poverty, Land and Agrarian Studies: Cape Town, South Africa, 2015.
17. Chitonge, H.; Mfune, O.; Umar, B.B.; Kajoba, G.M.; Banda, D.; Ntsebeza, L. Silent privatisation of customary land in Zambia: Opportunities for a few, challenges for many. *Soc. Dyn.* **2017**, *43*, 82–102. [CrossRef]
18. Whittal, J. A New Conceptual Model for the Continuum of Land Rights. *S. Afr. J. Geomat.* **2014**, *3*, 13–32.
19. Simbizi, M.C.D.; Bennett, R.M.; Zevenbergen, J. Land tenure security: Revisiting and refining the concept for Sub-Saharan Africa's rural poor. *Land Use Policy* **2014**, *36*, 231–238. [CrossRef]
20. Cousins, B. Contextualising the controversies: Dilemmas of communal tenure reform in post-apartheid South Africa. In *Land, Power & Custom: Controversies Generated by South Africa's Communal Land Rights Act*; Claasens, A., Cousins, B., Eds.; UCT Press: Cape Town, South Africa, 2008; pp. 3–31.
21. Lavigne Delville, P. Registering and administering customary land rights: Can we deal with complexity? In *Innovations in Land Rights Recognition, Administration, and Governance*; Deininger, K., Augustinus, C., Enemark, S., Munro-Faure, P., Eds.; The World Bank: Washington, DC, USA, 2010; pp. 28–42.
22. Rugege, S. Land Reform in South Africa: An Overview. *Int. J. Leg. Inf.* **2004**, *283*, 283–311. [CrossRef]
23. Cousins, B.; Cousins, T.; Hornby, D.; Kingwill, R.; Royston, L.; Smit, W. Will formalising property rights reduce poverty in South Africa's 'second economy'? *PLAAS Policy Br.* **2005**, *18*, 1–6.
24. Freudenberger, M.; Bruce, J.; Mawalma, B.; de Wit, P.; Boudreaux, K. The Future of Customary Tenure: Options for Policymakers. Available online: http://www.land-links.org/issue-brief/the-future-of-customary-tenure/ (accessed on 20 October 2016).
25. Cotula, L. Introduction. In *Changes in "Customary" Land Tenure Systems in Africa*; Cotula, L., Ed.; International Institute for Environment and Development: Stevenage, UK, 2007; pp. 5–14, ISBN 978-1-84369-657-5.
26. Cousins, B. More Than Socially Embedded: The Distinctive Character of "Communal Tenure" Regimes in South Africa and its Implications for Land Policy. *J. Agrar. Chang.* **2007**, *7*, 281–315. [CrossRef]
27. Foresight4Food Understanding Small-Scale Agriculture. Available online: https://www.foresight4food.net/understanding-small-scale-agriculture/ (accessed on 27 April 2022).
28. Woodhill, J.; Hasnain, S.; Griffith, A. Farmers and Food Systems: What Future for Small-Scale Agriculture? Environmental Change Institute, University of Oxford: Oxford, UK, 2020.
29. IFAD/UNEP. *Smallholders, Food Security and the Environment*; International Fund for Agricultural Development: Rome, Italy, 2013.
30. Ramalingam, B.; Hernandez, K.; Martin, P.P.; Faith, B. *Ten Frontier Technologies for International Development*; Institute of Development Studies: Brighton, UK, 2016.
31. Kambria The Next Frontier: Why Frontier Technologies Are Important. Available online: https://medium.com/kambria-network/the-next-frontier-why-frontier-technologies-are-important-f1456d8ef992 (accessed on 23 April 2022).
32. Gupta, M. Sen What is Digitization, Digitalization, and Digital Transformation. Available online: https://www.arcweb.com/blog/what-digitization-digitalization-digital-transformation (accessed on 3 August 2022).
33. Hapon, M. What Is the Difference Between Digitization, Digitalization and Digital Transformation [Updated]. Available online: https://www.netguru.com/blog/digitization-and-digitalization (accessed on 3 August 2022).
34. Asite Digitization, Digitalization, and Digital Transformation—What's the Difference? Available online: https://www.asite.com/blogs/digitization-digitalization-and-digital-transformation-whats-the-difference (accessed on 3 August 2022).
35. Bennett, R.; Pickering, M.; Sargent, J. Innovations in land data governance: Unstructured data, NOSQL, Blockchain, and big data analytics unpacked. In Proceedings of the 2018 World Bank Conference on Land and Poverty: Land Governance in an Interconnected World, Washington, DC, USA, 19–23 March 2018; The World Bank: Washington, DC, USA, 2018; pp. 1–36.
36. Holton, J.A. From Grounded Theory to Grounded Theorizing in Qualitative Research. In *The SAGE Handbook of Qualitative Business and Management Research Methods*; Cassell, C., Cunliffe, A., Grandy, G., Eds.; SAGE Publications Ltd.: London, UK, 2017; pp. 233–250.
37. Holton, J.A. The Coding Process and its Challenges. In *the SAGE Handbook of Grounded Theory*; Bryant, A., Charmaz, K., Eds.; SAGE Publications Ltd.: Los Angeles, CA, USA, 2007; pp. 265–290, ISBN 9781412923460.
38. Barry, M.; Roux, L. The Case Study Method in Examining Land Registration Usage. *Geomatica* **2013**, *67*, 9–20. [CrossRef]
39. Koeva, M.; Crommelinck, S.; Stöcker, C.; Crompvoets, J.; Ho, S.; Casiano, C.; Schwering, A.; Chipofya, M.C.; Jan, S.; Zein, T.; et al. Its4land—Innovative Geospatial Tools for Fit-for-Purpose Land Rights Mapping. In Proceedings of the 4th Annual Land Conference of the Institute of Land Administration, Bahir Dar, Ethiopia Bahir, 24–25 May 2019; Dar University: Bahir Dar, Ethiopia, 2019; pp. 1–18.
40. Stöcker, C.; Bennett, R.; Koeva, M.; Nex, F.; Zevenbergen, J. Scaling up UAVs for land administration: Towards the plateau of productivity. *Land Use Policy* **2022**, *114*, 105930. [CrossRef]
41. Hay, G. Cloud, Mobile and Big Data Technologies in Responsible Land Administration. In Proceedings of the 2016 World Bank Conference on Land and Poverty: Scaling up responsible land governance, Washington, DC, USA, 14–18 March 2016; The World Bank: Washington, DC, USA, 2016.

42. TerraFirma. *White Paper: The Application of the Community Land Value Chain (CaVaTeCo) to Land Tenure Formalisation Processes in Mozambique*; Terra Firma Ltd.: Maputo, Mozambique, 2017.
43. Tembo, E.; Sagashya, D. Zambia: Private sector investment in security of land tenure—from piloting using technology to National rollout. *Afr. J. L. Policy Geospat. Sci.* **2022**, *5*, 2657–2664. [CrossRef]
44. Chipofya, M.C.; Jan, S.; Schwering, A. SmartSkeMa: Scalable Documentation for Community and Customary Land Tenure. *Land* **2021**, *10*, 662. [CrossRef]
45. Eilola, S.; Käyhkö, N.; Fagerholm, N. Lessons learned from participatory land use planning with high-resolution remote sensing images in Tanzania: Practitioners' and participants' perspectives. *Land Use Policy* **2021**, *109*, 1105649. [CrossRef]
46. Galić, Z. LIS in the era of BDMS, distributed and cloud computing: Is it time for a complete redesign? *Coordinates* **2021**, 6–20.
47. Hughes, K.; Nishimwe, M.G.; Rutabayiro, S.N.; Mizero, R.; Akumuntu, A.; Muyombano, S.; Jones, J.; Mcgowan, K. Harnessing Technology to Advance Citizen-Centric Land Administration in Rwanda. *Afr. J. Land Policy Geospat. Sci.* **2022**, *5*, 344–354.
48. Enemark, S.; Bell, K.; Lemmen, C.; McLaren, R. *Fit-for-Purpose Land Administration*; Enemark, S., Ed.; International Federation of Surveyors: Copenhagen, Denmark, 2014; ISBN 9788792853103.