Agency and Extraction in Emerging Industrial Drone Applications: Imaginaries of Rwandan Farm Workers and Community Members

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Rapidly diffusing 'industry 4.0' technologies stand to impact a broad range of stakeholders. Prior to implementation, forward looking formative analyses can identify systems and policy designs to promote equitable benefit. We investigate this potential through an analysis of stakeholders to a potential drone implementation on a small commercial farm in Rwanda. Translating stakeholders' imaginaries within a post-colonial frame, we identify hopes and concerns related to agency and influenced by global and local systems of power. The findings highlight constraints that recommend system designs promoting local agency and control and policies designed to balance local data management against potentially 'extractive' multinational data transfer processes.

CCS Concepts: • **Human-centered computing → Human computer interaction (HCI)**; User studies.

Additional Key Words and Phrases: ICTD, Africa, Rwanda, Drones

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1 INTRODUCTION

As 'industry 4.0' technologies, such as unmanned vehicles, diffuse beyond sequestered industrial applications and become commonplace tools, they stand to impact a broad range of stakeholders. This is particularly true in settings where technologies serve as extractive tools [56], collecting data with little regard for notions of justice, where they may become a source of contention for relationships between communities, employers, and workers. In the so-called Global South, these contentions may derive from international power differentials and roles in global IT production

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systems. The effects of the assemblages [37] in which these technologies are embedded, can reach beyond users of the technologies and are difficult to anticipate and diagnose [20].

In this paper, our research setting is in and around Kigali, Rwanda, where different drone assemblages are being (or in some cases beginning) to be used for a variety of applications (e.g., transporting blood and medicine, or for agricultural purposes) [6, 19, 27, 28]. Rwanda particularly is serving as a testing ground for companies hoping to expand across the continent [6, 19]. Some of these companies – utilizing unmanned vehicles or drones – are headquartered outside of Africa, testing the drones in order to gather training data and experimenting with proof-of-concept designs. This mining of local data and settings, can be seen as an extractive process [56], one in which Rwandans may receive some economic value, but the greatest value accrues to multinational firms. The work of Mann & Nzayisenga highlights this phenomena, where they observed how the informal networks constructed by Rwandan mobile phone airtime sellers "can be used as temporary appendages to further the reach of formal multinational corporations," and called for these value chains and networks to be "re-engineered to provide permanent and sustainable livelihoods" for the base of the economy.

Given these conditions, it is important to gather insights and interact with a wider range of stakeholders *before* the assemblages are deployed, so that the various interests (e.g., governments, businesses, designers) can more formatively uncover potential issues. In turn, this process can inform policies designed to reflect and mitigate these issues and promote technical designs more sensitive to the values of the wider population. To gather these insights before the system has been deployed, we use imaginaries [22, 41, 50] – expectations for and anxieties about new technologies – as a means for interacting with different stakeholders that have different levels of both experience and expertise in agriculture and with drones. This enables us to go beyond usability evaluations of the prototyped devices, and begins to unpack the social and historical context in which the technology will be deployed and the constraints that this imposes on beneficial, sensitive, and ultimately successful designs.

In our study, we find a clear tension between whether the deployment of the technology is something being done to, done for, or done by the participants and their community. This tension is expressed through the questions participants asked us and their musings around the amount of agency they would have over the evolution and use of the technology. That is, studies of drones and autonomous robots frequently target use within urban contexts or developed countries [27], largely overlooking low-resource communities. This is particularly true of studies that have focused on autonomous drones for commercial farms [38]. As such, the concerns uncovered around these assemblages have largely focused around privacy [13, 21, 66]. In contrast, the participants in our evaluation have a different set of concerns, which are related to the lack of control the participants feel towards the development and use of a technology that originates from outside their borders. So, while their concerns do include privacy, they more prominently feature safety, affordability, repair-ability, agency, and economic displacement. This different set of concerns is firmly rooted with their previous experiences with technology, something which we found imaginaries to evoke these collective memories [29, 55] quite well. That is, as participants imagined different outcomes, they related these outcomes to previous experiences and histories with other related technologies.

In this paper, we give an overview of the context and partners of our study, our analytic outlook, our findings, and discuss the wider implications of our findings. Specifically, our contributions in this paper are twofold. First, we illustrate how tying imaginaries with critical studies and an expanded range of stakeholder groups generated a wider variety of imaginaries, and this combination helped us to analyze a socio-technical assemblage before it was deployed. Engaging stakeholders through these imaginaries, helped us to understand the broader assemblages that these drones would be a part of, highlighting the multiple levels of power and the different roles of agency for the individuals,

communities, and country. This process creates a more democratic design process [9, 20] whose analysis provides inspiration for more equitable designs and policy-making that benefits the public good, and not just the multinational corporations deploying the technology and extracting value. Second, we highlight how understanding the first hand accounts of participants helps to uncover which functionalities are invisible and may render stakeholders' observations incomplete, which may be a sign of future issues. In our case, analyzing and considering the assemblage that the drone would be a part of, exposed data extraction practices about which our participants, by way of omission, appear unaware.

1.1 ICTs, Drones, and Agriculture in Rwanda

New technologies feature prominently in the Rwandan government's development plans. In 2010, the government put information and communication technologies at the heart of its 'Vision 2020' economic development strategy [26, 51]. For 2050, 'industry 4.0' technologies, such as robotics, the Internet of Things, and drones, take center stage [4]. Partly as a result of this, the country is preparing for the deluge of data these technologies generate through its 2017 National Data Revolution Policy [1]. The policy lays out objectives for open government data, providing broad guidance on governance, technology management, and use. The policy states, "Data revolution [sic] will embrace the principle of national data sovereignty whereby Rwanda shall retain exclusive sovereign rights on her national data with control and power over own data." This mention of 'data sovereignty' appears to have generated concern in commercial sectors [57], but its impacts for international commercial data transfers as yet are unclear.

In support of its 'high tech' development approach, Rwanda's drone policy, co-designed with the World Economic Forum, serves as an international standard due to its agile nature [15]. It provides commercial drone operators with mission-specific safety standards, allowing them to continuously innovate to meet the standard. This more nimble, performance-based regulation effectively allows use of state-of-the-art drone technology and provides more timely access to airspace [54]. Rwanda's nimble policy environment was informed by early entry of the U.S.-based firm Zipline, which worked with the government to pilot its drone-based blood and medical supply business in the country [6, 43]. In an ongoing and highly publicized relationship, Rwanda's Ministry of Health contracts Zipline to deliver supplies to rural hospitals. In addition to local coverage, global media have contributed to the renown of the innovative service with stories featured in The Guardian, Christian Science Monitor, PBS, MIT Technology Review, Time and Fortune magazines, among others.

The use of drones is one of the latest strategies in Rwanda's push to modernize its agricultural sector. Historically, starting with tractors and mechanization in the post-colonial period [10], modernizing agriculture has been and continues to be a struggle across sub-Saharan Africa. Early efforts often failed due to underdeveloped fuel supply chains and limited repair expertise. As a result, broken-down tractors stranded in fields became a symbol of inappropriate technology-led development [34] and in our experience seemed to serve as a material memory [55]. Rwanda, known as the 'land of 1000 hills' is especially unsuitable to traditional large-scale tractor-based farming, which is partly the motivation for seeking alternative technology development paths. More recent East African experience with ubiquitous mobile phones has further highlighted issues of parts availability and the role of repair in broader global production systems [31, 65].

Agriculture in Rwanda is considered the country's economic backbone and is critical to mitigating problems with food insecurity [3] as well as contributing to exports [2]. There is a mix of large and small commercial farms, growing products for local consumption, as well as coffee, tea, and flowers for export [2]. However, the bulk of agricultural production is undertaken by the over 70% of Rwandans involved in subsistence farming, consuming the food they produce. In peri-urban

areas, subsistence farmers toil alongside Rwanda's increasing urbanisation [23]. Researchers and policymakers have focused on peri-urban agriculture as a mechanism for urban sustainability and reducing food insecurity [16, 23, 36]. Innovative agricultural technology, such as drones or robotics, have been lauded for their potential to increase sustainable food systems within these areas [14, 17, 47]. The objective of drone-based precision agriculture is to afford farmers with the ability to micromanage and plan farm operations [46, 49]. In particular, precision agriculture have been found to increase crop production [48], while reducing the use of pesticides, fertilizers, and other valuable agricultural resources [19, 59]. Drones and autonomous robots in precision agriculture has the potential to assist farmers with both primary tasks (e.g., harvesting or spraying pesticides) and secondary farming tasks focused on agricultural maintenance [14]. However, research on general drone use suggests unequal access to and use of drones for precision agriculture may diminish their potential benefits [62].

Given the potential positive benefits, the Rwandan government supports several initiatives promoting autonomous devices and sensors in agriculture[1]. Once example is the 2019 collaboration with Rwandan owned and operated Charis UAS[2].

2 ANALYTIC FRAMING

Against this backdrop, we investigate perceptions of both unmanned aerial and ground drones (UAV and UGV respectively), among casual workers and community members. Our investigation engages these potential observers, beneficiaries, and sufferers of drone use in a formative analysis, generating insights for design and policy making. Our framing for this investigation draws upon a novel combination of scholarship from imaginaries – stakeholders' visions of the future – together with critical technologies studies in the context of international development.

In this analysis, we also draw inspiration for interacting with a wider set of stakeholders from the business ethics domain [25, 35]. A critical piece of this theory is to balance the interests of all stakeholders [5], and this balance is achieved by varying the scope of stakeholders involved in the analysis, where theorists have proposed a *wide* definition and a *narrow* definition of a stakeholder [8, 24]. In this paper we utilize a *wider* definition, where a stakeholder is defined as any identifiable group or individual who can or is affected by the organization's objectives [24].

2.1 Sociotechnical Imaginaries

Sociotechnical imaginaries are the conceptions of, expectations for, and anxieties about technologies, which highlight peoples' fascinations with technology, which can sometimes be illusory or diffuse [50]. Imaginaries often are associated with communities and groups, having a collective basis generated through popular discourse via the Internet or mass media [22, 41, 50]. Imaginaries are central to both design and policy-making [64]. In CSCW, the construct motivates research on conceptions developed through digital technologies as well as about these technologies, including online Real Money Trade in Chinese gold mining [50], transnational IT work [42], internet health information-seeking [22], wireless spectrum [64], and distributed ledger technologies (e.g., Blockchain) [44].

Among these, our work is most closely aligned with Lindtner et al.'s [42] melding of imaginaries and technical appropriation perspectives in research on transnational IT work, and Wong and Jackson's [64] use of imaginaries in analyzing spectrum policy. The former investigate 'transnational imagination,' as derived from the global movement of ideas, objects and lifestyle choices, in IT appropriation among IT workers and entrepreneurs in China. They recognize and analyze the role

[1] http://rcidcentre.com/
[2] https://charisuas.com

of international corporations and translocal collaborations as vehicles for the movement of ideas and values, which in turn shape appropriation. They find transnational imagination highlights connections across places, as well as frictions, as factors influencing the technical appropriation process. Further, they emphasize the negotiation between cultural values, and economic, political, and social interests, as fundamental to the appropriation process. In sum, the design and use of technologies are sites of negotiations.

Wong and Jackson [64] find imaginaries situate technological projects and developments within a larger societal context. They recognize sociotechnical imaginaries as shaped by diverse stakeholders, including designers and researchers, as well as policymakers and other policy stakeholders. Further, Wong and Jackson [64] note imaginaries' relationship between cultural and social imaginations and the goals, priorities, and benefits of technology, wherein the latter are shaped by wider and sometimes contested social and cultural arrangements. The research finds imaginaries influence technology policy and inspire design by integrating visions of stakeholders, users, and the public good. Imaginaries are broad in scope, emergent, and open to a wide range of collective and individual psychosocial underpinnings. In some cases, positive imaginaries may be tied to aspirations, both individual and collective. Recent scholarship positions aspirations as a more appropriate framework for projects linking technology and international development [39, 60].

While drawing on these findings, our research departs from existing CSCW imaginaries research in three important respects. First, while previous scholarship emphasized imaginaries as 'collectively-held notions,' we assert those notions were based on assumptions of ubiquitous access to information. In contrast, our research context is characterized by the heterogeneous distribution of information common in low-income contexts. Second, while previous research has focused on stakeholder diversity, that diversity largely is limited to sub-groups of elites, namely users, IT developers and recognized policy stakeholders. Our research examines imaginaries among stakeholders who are not yet direct users and may never be. Third, as presented below, our framing interprets the imaginaries of these diverse stakeholders through the lens of critical technology studies from the postcolonial field. In doing so, we build upon the transnational perspective of Lindtner et al. [41], integrating theory that more directly addresses the relationship between technology and relations between the Global North and South.

2.2 Power Differentials, Assemblages and Extraction

As a complement to imaginaries, we integrate concepts from the three related fields of postcolonial computing, ICT4D, and critical data studies. Concepts central to our analysis include (1) the recognition of power structures and their relationship to perceptions of technology in a so-called developing country context, (2) an ensemble view of technology, also referred to as assemblages, and (3) the role extraction plays in analyzing the impact of new technologies, in this case drones.

Postcolonial computing emphasizes the power and cultural differentials encountered in research between the economically developed countries of the 'North' and the 'less developed' countries of 'Global South.' Postcolonial computing proposes an alternative sensibility in the design and analytic process [33], recognizing the power structures permeate and have influence at multiple levels, from multi-national institutional environments to individual level participatory design efforts. Postcolonial computing, similar to critical ICT4D research [40, 67], promotes balance between competing interpretations of the effects of these structures. On the one hand, influenced by theories of colonization, development, and theories of change [18, 67], they highlight these structures' potential harms in hindering self-reliance, limiting economic progress, and reinforcing both international and domestic inequality. On the other, these scholars explicitly recognize such effects do not imply individuals, communities or entire societies are devoid of agency or the capacity to develop. As such, research focuses on engagement and translation, understanding statements

about technology and 'engaging with people on their own terms' [18, 33]. Going further, in some contexts, Western design orientations are replaced by indigenous design approaches, emphasizing collective benefits and consensus [63].

Power structures are also central to critical data studies, which provides a complementary narrative to 'Big Data' science. From this perspective, drones, as tools of remote sensing and data acquisition, can be seen as playing a role in broader 'data economies' [61]. Critical data studies question and analyze the trajectory and final destination of the Big Data phenomenon, assessing costs and benefits, and to whom they accrue, as well as data's interactions with society and social processes [32].

To understand diverse sources of power, all three fields embrace the 'ensemble view' [52] of technology adopted here. In national development, the ensemble perspective views ICT as a production network and a system of alliances between disparate groups, shaped by social and contextual elements [58]. In critical data studies, the view is even more expansive, proposing the concept of 'assemblages.' Assemblages consist of the technological, political, social and economic apparatuses and elements that constitute and frame the generation, circulation and deployment of data [37]. These assemblages evolve and consist of a variety of apparatus and their constituent elements. Apparatus and elements include, for example, organizations and institutions, and constituent entities such as archives, corporations, and communities of practice.

The assemblages of the global agricultural sector's emerging data-based technologies, including remote sensing, mobile applications, and drones, raise a variety of questions concerning data privacy and ownership, with implications for power in relationships between stakeholders [11, 12]. In Western contexts, the potential for data to further entrench power in large agricultural equipment manufacturers generates another dimension of concern for the future of small farms [12].

The confluence of data gathering, collection and accumulation, within contexts of unequal power in the Global South calls to mind processes of extraction associated with colonialism. Historically, colonial powers extracted valuable resources, generating greater wealth differentials, in turn further entrenching their dominance. As relates to the assemblages of data, Sadowski [56] notes systematic data accumulation's relationship to economic processes creates opportunities for exploitation. He argues data accumulation is in reality 'data extraction,' occurring with little regard for consent and compensation. Madianou goes further, positioning data extraction as a fundamental process of technocolonialsm, replicating historical relationships of extraction from marginalized to wealthy communities [45]. The process involves extraction not only of the data itself, but also the value derived from analytics. Wealth generated from that value is rarely shared, considered private capital in the neoliberal global economy. Antidotes to extraction are articulated in the emerging field of 'data justice for development' [30] and Indigenous Data Sovereignty, which questions "current approaches to data ownership, licensing, and use in ways that resonate beyond Indigenous contexts, drawing attention to the power and post-colonial dynamics within many data agendas" [53].

In addition to commercial and economic development undertakings, academic research itself can be extractive. Postcolonial computing views traditional design research activities, such as collecting design requirements, lessons learned and knowledge gained, as extractive, which the approach seeks to avoid [33].

3 METHOD

This research was embedded in a relationship between our team, a small commercial floriculture farm, and the adjacent community. The farm itself is a Japanese company that is licensed in Rwanda, and has been collaborating with foreign entities interested in the design, development, and deployment of agricultural autonomous robots and drones. However, the farm itself is only a test-bed and neither the farm nor our research team is directly involved in the development of this

drone. In fact, the owner of the farm engaged with us because they were concerned with how the deployment and use of the drones would be perceived by the farm staff, casual workers, and the adjacent community, and the impact of this perception on the farm's standing with the community.

Due to our relationship with the farm, we were able to witness trials of the UGV on the farm and learn that the future objective for the device is primarily to monitor plant growth. The UGV would do this by gathering visual data from cameras to train a machine learning model that could gather and ultimately determine the impact of the various experimental conditions being used to grow the flowers. These flowers, being grown on the farm, are not indigenous to Rwanda, and hence the horticultural expertise resides abroad. Consequently, in (at least) the early states of using the drones, the data are being sent to research labs abroad for model development. While the UGV development was only in the early stages of deployment and testing during our research, we can say that presently the capabilities of the autonomous robot do not overlap with the work completed by the casual workers or the administrators, however it does perform similar tasks as the agronomists. Currently, the agronomists use pen and paper to manually record the experimental conditions of individual plots, the GPS coordinates, as well as the health and growth rate of the plants.

The employees on the farm (e.g., administrators, agronomists, and casual workers) are all Rwandan. Several of our participants stated they have seen the autonomous robots operating on the farm, but few were able to interact with or ask questions about the drone. The organizational structure of the farm includes, administrators ($n = 2$), agronomists($n = 4$), and casual workers($n = 30 - 60$). The casual workers range from 30 in the off-season to 60 during peak-season (e.g., harvesting or picking) – casual workers are essentially day laborers and have no set number of hours or salary. Given the proximity of the farm to the community members nearby, several of the casual workers we interviewed came from the same communities. Given the support of the farm owner for the research, farm employees were able to participate during their paid work time. That said, in order to protect the identity of our participants we never recorded their names and the owner of the farm did not have access to the data (nor did any other employees).

We gathered field observations and semi-structured interview responses from casual workers ($n = 26$) and nearby community members ($n = 20$) to better understand their experiences with, attitudes toward, and expectations about the potential impact of autonomous drones in agriculture. The interviews were conducted in Kinyarwanda, the interview team included two researchers from Rwanda who are fluent in Kinyarwanda. We used a semi-structured interview protocol, during which we brought two drones (one flying and one ground) and presented videos that showed similar drones performing agricultural tasks. To enhance engagement and promote clarity of meaning and functionalities, we developed a non-functional full-scale drone prototypes. Our ground drone prototype was based on the version previously tested at the farm, it consisted of a modified radio controlled toy with a 3-D printed faux GPS, two antennas, a camera, and a plastic box with clear sides containing the battery, additional wires, and motherboard. We also used a non-functional flying drone as prototype, namely a Holy Stone drone which is a small, light-weight, and quad-rotar drone[3]. The drone from the video was an agricultural drone called the *Blue Grass* by Parrot[4]. Participants were encouraged to touch and pickup the drones to examine them.

In this paper, we have grouped our 46 participants into 4 different groups: for the 26 farm employees, we split them into 5 staff workers and 21 casual workers; for the 20 community members, we split them into 7 who happened to be farmers and 13 who were not farmers. While we had anticipated only 3 groups (i.e. community as one group), we found that the farmers in the community had a unique perspective as they had domain expertise in farming, but were going to

[3]http://www.holystone.com/en/Drones/Big.html

[4]https://www.parrot.com/business-solutions-us/parrot-professional/parrot-bluegrass

be less immediately impacted by the deployment of the drone on the commercial farm and had a much different power relationship with the farm and researchers. The field observations included the participants' interaction with the drones and autonomous vehicles, as well as their interactions with other information technologies that may be incidental to the use of these devices on the farm.

In recruiting community members, we drew from two nearby communities, we formally asked the the community leaders and to foster engagement participated in 'Umuganda' for two of the three communities. Umuganda is a community-oriented volunteering event held on the last Saturday of every month to work on communal tasks such as maintaining a road or building houses of the poor[5]. The community leaders introduced us to the rest of the community members during the town forum at the end of Umuganda, and announced that we would be conducting research on their perceptions about the usage of technology in agriculture and that participation in our study would be voluntary. These community leaders also accompanied us during the majority of the studies conducted with the community participants.

For each interview, we performed the following steps: we introduced ourselves using a standardized script that introduces the purpose of our study, the members of the research team, compensation, and the data that we would be gathering from the participant; we asked several questions about prior knowledge and perceptions about drones; we showed them the two videos of 1) an agricultural autonomous robot operating at the farm, and 2) an agricultural drone flying above a crop field; we showed them the prototype drones and invited them to handle them; and finally, we asked follow-up questions and had an open discussion with participants. Throughout the process, participants were encouraged to ask questions related to our study, the drone prototypes, and general information about autonomous robots and drones. These protocols and the overall research project were vetted by human subjects research boards at a U.S. university, as well as Rwanda's equivalent, the Rwanda National Ethics Committee (RNEC). It is worth noting, that at the end of each interview we did not necessarily dispel any fears or concerns that they had during our interaction, some (even many) of their fears were valid and from our decolonized perspective we felt we should not be making statements about aspects of the assemblages that we do not know for certain or fully understand.

The data, entered in notebooks, were entered into a shared spreadsheet to aid consistency checking. We iteratively coded the data to identify themes by the data collection team, as well as more senior members. During the coding process authors met weekly to discuss the codes and come to a consensus.

4 FINDINGS

In this section, we group our findings into three of the main themes of our analysis. First, are the different historical and social factors that made up the context into which these drones would be deployed. Second, we outline the different ways that participants imagined the drones would be used and for what purpose. Lastly, we illustrate the ways that participants imagined the levels of agency that they would have over the drones and assemblages.

4.1 Understanding Existing Attitudes and Context

All of our participants had knowledge of or experience with drones being used for various purposes in Rwanda. Drone use, particularly in agriculture and medicine, was being lauded by the government as a way to improve quality of life and access to resources in Rwanda. As we talked with participants, we came to appreciate the historical and social context that was particular to Rwanda, i.e., their collective memory [29]. Many of the requirements for integrating drones into a beneficial and sensitive assemblage, would have to understand and reckon with this context of which these

[5]http://www.rgb.rw/index.php?id=37

memories were part. In this section, we outline the various aspects that informed the participants' existing knowledge and attitudes towards these drone assemblages.

4.1.1 Informed by Experience with Zipline. Due to the high amount of news coverage of Zipline, our participants had knowledge that drones were being used to deliver blood in Rwanda, which somewhat predisposed them to regarding drones as a potentially positive force. Understanding the influence of this media exposure and general attitudes towards drones is necessary and valuable to deploying new assemblages, as the starting point for most of the users and surrounding community would be heavily informed by this use case. We saw these responses across all of the stakeholders, and a clear trend towards regarding drones positively if they can provide a service as valuable as medicine and blood in an emergency.

> I hear them – delivering drones (Zipline drones) at CHKL hospital. They are good if they deliver blood - *Casual Worker 4*

Here we see the transitive nature of this positive outlook on drones from the medical to the agricultural domain.

> Have never seen it here, heard of it in health at the hospital delivering blood. I feel they make research and work in agriculture faster. - *Staff 4*

The government had a particularly strong hand in publicizing these new technologies and framing them as a more positive force than is associated with drones as tools of war.

> I saw them on TV, President was launching Zipline. I thought they were to be used in war only and now was amazed that they can be used in agriculture and helping deliver blood and more important things. - *Community Farmer 6*

Sometimes this cursory exposure to drone technology led to misunderstandings that all drones' – i.e. not just Zipline's drones – primary purpose is for transporting blood/medicine, or facilitated misunderstandings about the current state-of-the-art.

> I have heard people talking about them only, heard they take blood only. - *Casual Worker 8*

> Have seen some drop blood, maybe it's the only use. Only see them on TV though. - *Community Member 1*

> I heard of drones you speak to and give it your problem and it brings you medicine after some time. - *Community Farmer 2*

The visibility and awareness of drones influences how participants create imaginaries, in this case drones have clearly entered the conscience of many people in Rwanda. Talking to a wide range of stakeholders is essential to understand how common and unique aspects of culture express themselves in relation to the assemblage in question. Clearly, in this case there is a path for drones as positive forces in Rwandan society that can help mitigate material problems that Rwandans are experiencing (e.g., blood deliveries or perhaps food insecurities).

4.1.2 Informed by Aspirations of Being an Advanced Society. As part of the publicity and framing of drones by the media and government, they are being associated with progress and becoming a more advanced society/country, which many Rwandans seemed to aspire to. Clearly, the use of drones in agriculture connoted advancement and the future, and in some cases a bit of prestige. This connotation, was seen as valuable in and of itself, and in some cases was part of the calculus as to whether or not the drones should be deployed. This was true to the extent that using more advanced technology even brought more meaning to the job itself.

> [The use of drones] would be happy. It would mean my work is important, they have even brought this robot to help me do it very well. - *Casual Worker 20*

> [The use of drones] is surprising. I studied agriculture but I never learned about drones, now we're using drones. It means we're advancing. - *Staff 4*

> I would want to now start agriculture again, since this will excite me to start agriculture again - *Community Farmer 4*

Sometimes, drones were seen as an integral part of mitigating severe issues being experienced by Rwandan society.

> My husband told me about them. Rwanda is advancing, hunger is going to end in Rwanda was my idea, because it can produce more food. - *Community Member 6*

This optimism was not without skepticism, but was almost always tempered with using technology as advancing and being an end in and of itself.

> I would feel the farm is advancing and using technology, maybe it's taking pictures of the farm. Maybe it's measuring the farm too. I would be inquisitive to know what it is doing or even touch it. - *Community Member 8*

4.1.3 Informed by Experiences with Automation. Although participants had a familiarity and perhaps predisposition to viewing the drones as a positive signal of advancement and prosperity, this is not the first time that the promise of automation has been made to Rwandans, particularly the day laborers. The perspective brought by their experiences and history with farm automation (e.g., tractors or rototillers that were difficult to repair) mean that the day laborers' attitudes towards automation varied considerably. On one hand, some workers when asked about their experiences with automation of course like that the work went faster and was easier with the automation:

> I think you use less money, when you use tractors cause it farms big in less time, compared to one using just a hoe. - *Casual Worker 8*

> With tractors, it makes my work easier, digging with a hoe is hard, removing weeds and grass is also easier. - *Casual Worker 5*

On the other hand some workers cited that even though the tractors were fast, workers often had to correct a lot of mistakes that these machines made.

> [I would rather work] without [rototillers], because it plants badly, misses a lot of planting points, people are better. - *Casual Worker 4*

> They rush very fast, a hoe is precise and accurate, tractors are fast and skips some points. Prefer using hoes on the farm. - *Casual Worker 6*

What this is starting to show is a skepticism around the ability of technologies, particularly automation technologies, to deliver on those promises. Noticeably, this perspective only came from one of the stakeholder groups, the workers themselves, and shows the importance of widely surveying stakeholder groups. This shows that perhaps the optimism shown by more indirectly impacted stakeholder groups should be tempered by the histories experienced by more directly impacted stakeholder groups. That is, while other stakeholder groups had a healthy dose of skepticism around the capabilities of drones (e.g., to carry a lot of water), none had quite as much experience dealing with existing technologies as workers who were more attuned to the potential mistakes and drawbacks of just using automation. This insight provides potential directions for various interests to better frame expectations and more realistically evaluate the promises made by system developers. Additionally, this shows that imaginaries are in fact useful to find notions that are *not* collectively-held.

4.2 Imagining Impact and Use of Drones

Having the drone prototypes with us during the interviews, helped participants to imagine their uses and realize the validity of some existing concerns and uncover new ones as well. What we felt was particularly important in these imaginaries was to prompt for both positive and negative thinking throughout the protocol, this helped to map out the areas that might be problematic in the future and would need attention from policy makers and designers.

4.2.1 Utility of Drones. Different stakeholders valued different aspects of the drone, and there were clearly uses that they would appreciate. The staff on the farm was particularly positive about the technology, as they were less immediately concerned with job loss, and in some cases seemed to be in conflict with the casual workers. Some staff members imagined that the drones would help them by efficiently gathering more information with which to make better decisions.

> [W]e are facing some pests and disease, some are unknown at the moment, but having a device related to the tech is, is better to have it so we can boost the production to know which pests are we facing, so that we can not lose our production - *Staff 3*

> If this was on the farm, I would appreciate it to immediately have information on the farm, to this drone. It's not time consuming. For a few minutes you can survey your farm, without moving, moving 10 km, but these drones can do it within a few minutes, so if we can have it it would be better. - *Staff 2*

While others, saw it as a way to eliminate the need to deal with the labor force.

> They make my job very easy to do, because I can monitor them instead of, it's very different than working with people, you have to train people, you have to yell at people, the casual workers - *Staff 2*

A stakeholder for whom the deployment of the drones seemed more immediate and threatening were the casual workers on the farm. Here however, they did hope that perhaps the drones could perform and take over some of the more dangerous tasks that casual workers were currently doing, such as spraying pesticides. Clearly, they were valuing a decreased risk to their health, which highlights the tasks that are ripe for automation.

> It will help us by reducing work in spraying the pesticides is heavy to carry and also sometimes dangerous to our lives, it will help us be more effective. - *Casual Worker 4*

> I think it would help in spraying dangerous pesticides. It can see where there are weeds - *Casual Worker 6*

Workers' options also paralleled that of the staff, and also valued the potential information that the drones would gather, for a variety of reasons. Some, imagined that the information would help with tasks that require precision and are error prone.

> It is good, we needed to measure flowers and there are many errors, this will reduce them. - *Casual Worker 12*

While some, imagined it would help keep an eye on casual workers that were not doing their fair share of the work on the farm:

> I would feel happy, because it's evaluating us and all of us will be doing good work, some people don't do good work - *Casual Worker 8*

Any business that was deploying these drones, would need to contend with both the negative and positive expectations that members of their organization had.

4.2.2 Concerns with Safety. One concern about drone use that was primarily expressed by the surrounding community was the safety of the drones. Surveying a broader set of stakeholders uncovered this concern, which was not mentioned by stakeholders directly involved with the farm. These types of concerns may be difficult to design around, however, policies and public communication around how the drones are used and their capabilities could ameliorate some concerns. Yet, the real risks should be clearly communicated. Safety was a clear and legitimate concern with these drones, particularly if it got in an accident or hit a child (regardless of whether it was the ground or aerial drone):

> It can get in an accident easily in the air. - *Community Farmers 1*
>
> I'm concerned about how it moves, a child might be knocked by the UGV. The box with the batteries...I don't know why the wires are outside and what it is. - *Community Farmers 2*
>
> I would be comfortable with UAV, because it can never knock my kid, but in the air no accidents with my kids. - *Community Members 12*
>
> It moves too fast in the sky and also if no pilot, it can easily fall. The battery can also black out. The fact that it can be driver-less concerns me. The security of my produce, it can make accidents easily. What if the battery runs out? - *Community Farmers 4*

There were also concerns about how well the drone could actually do tasks, e.g., would it be sloppy in spraying pesticides and impacting others' farms and/or health. Here, we were able to compare comfort levels between aerial and ground vehicles.

> [It] might spray pesticides on my side by mistake but UGV is restricted to the farm it's working on - *Community Farmers 5*
>
> UGV - Why: the UAV might spray in the wrong places outside the farm and spray it on my cows but the UGV is restricted to my neighbors farm. - *Community Farmers 6*

Another closely related concern, that has been seen in various drone studies, was how much the drone would respect privacy. Participants were concerned about the drone recording images or audio.

> I am concerned, this robot might even be taking my pictures or recording my audios. - *Community Farmers 3*
>
> I would feel it's invasive since this place is small. It is better they use it on big farms, not small farms like here. I would think government is taking pictures/information, if it was in a nearby farm. I would feel a bit insecure too. - *Community Members 4*
>
> [My concern] is the camera. It might take all pictures, even those it isn't supposed to take. - *Community Members 12*

In this setting, surveying additional stakeholder groups showed that to be successful and accepted by the surrounding community, the deployment of these drones would need to be done carefully and be sensitive to the safety concerns of community members. This is perhaps more important in this particular setting, as the workforce is fairly fluid and a community member one day may be a worker the next.

4.2.3 Job Fears and Impact on Work. Clearly, the threat of automation felt the most immediate and real to the casual workers who performed most of the manual tasks, and as such they were clearly concerned about the possibility of drones replacing them and taking jobs away. We note here, that in our understanding of this particular application of drones they do not seem to be a threat to casual workers' jobs, however, this again highlights the need for careful communication and perhaps more affordances that make the tasks the drone is designed for more obvious and

observable. It is also worth noting, that there is a large power differential between the researchers and casual workers, additionally, we interviewed the employees on the farm, so their responses may have been influenced by this, that is, saying nice things about the technology since it was what the 'boss' was using. We assured them that their privacy was being protected and did not record their name, nor did we share the data with the farm owner. So, while there is an element of optimism associated with technological progress, it is accompanied by a very real fear of job loss or economic displacement. This is clear in some of their comments, where the workers were wrestling with what the impacts would be to them or members of their stakeholder group, these workers' feelings ranged the complete gamut from positive (as we saw previously), cautiously optimistic, to dread.

> It's amazing, it's like a miracle from God. Good effects because work will be good. However, personally I think it will take some of our jobs. - *Casual Worker 5*

> I think they have come to evaluate our work, it has come to report us to the boss. If you see it, you better start working harder, because it has a camera and can see you - *Casual Worker 15*

> I still fear losing my job, unless I can operate the drone. - *Casual Worker 3*

This concern about jobs was somewhat echoed by the surrounding community, but there was a common feeling that the jobs were menial, so it would not be a big loss anyway.

> The people won't be overworked and don't grow old easily due to stress - *Community Farmers 5*

> Locals will have hope and will live longer, as they will not be overworked in their youth. It's better life in general. - *Community Farmers 6*

However, not all community members were flippant with others' jobs, they worried who was going to be controlling the drones and who in the end was going to benefit from them.

> How can you help someone [...] that cannot even afford some things to be able to buy a drone? Aren't these drones going to take people's jobs, for example, if a person fetches people water, a drone can come and take/fetch more water faster meaning people might lose jobs and become poorer! It is going to remove the small jobs away and the rich will get richer. - *Community Member 12*

> I would be happy. Farming is stressing and hard. It will make work easy. It is good only for the rich, however for the poor person they will die cause the daily income is now gone. It is for the educated, and casual workers will die. - *Community Farmers 3*

This concern was echoed by some of the workers, and at times transitioned into them wondering aloud what the consequences would be of their imaginaries.

> I want to plan for the future and start saving early, since it will take my job when it's implemented [...] Other people are going to benefit from this tech, not me. - *Casual Worker 16*

> How are you helping [day laborers]? Like in our farm of course, [...] for our Rwandan farmers, [...] the ones who don't they have never heard in their ears about drones [...] What will that worker, the ones who don't know anything about fertilizer or pesticide use? How will this project help him or her? - *Staff 4*

> Will drones come to help us or to improve on our current work? Will you get 10 workers and they use 1 drone to spray or will it be approximately 5 workers that will be replaced by 1 drone? - *Casual Worker 11*

One thing that we began to notice in our post-interview analysis, is that no one mentioned the danger of drones to knowledge work jobs – i.e. the ones that the more educated farm staff held and seemed to actually be in danger. This perception occured even though the purpose of the drone is in large part to automate some of the analysis done by farm staff, and less so the jobs of the planting and spraying of pesticides on the farm. Furthermore, the physical structure of the UGV included a camera and no mechanical arms or other mechanistic devices that would suggest it performing these more manual tasks. A theme that did occur often and across stakeholders was how much control they were going to have on the technology and its consequences, which we outline in the following section.

4.3 Imagining Agency

One of the aspects of our interviews that we noticed while analyzing the transcripts – and not so much while doing the interview – is how much we were being interviewed by the participants about what was going on in their community. It seemed to us that they were trying to figure out, who was behind the drones and what were the goals of the different stakeholders. In essence, they were trying to figure out if the drones would be something they had to deal with, that they benefited from, or that they could control or develop in a meaningful way.

4.3.1 Who is Building and Operating the Drones. Participants voiced curiosity or concerns about drones being deployed by or to the benefit of the foreigners. Here participants use the word "muzungu", which usually means a European looking person and "Chinese" is usually anyone who is Asian. However, muzungu, can be any foreigner or, say, a wealthy Rwandan who is affecting like a foreigner. In particular, here the operators were Japanese and they were calling them mazungu. Use of the term was observed among the participants across different stakeholder groups.

There was a clear language and power barrier between the casual workers and the foreigners who were testing and using the drones.

> Not sure, the Muzungu was operating it. I never asked what it was for. I fear asking muzungu due to language barrier. I heard it was for measuring flower length. - Casual Worker 5

> Yes, muzungu had it in the flowers, it was just moving in the flowers. I think it was taking pictures - *Casual Worker 21*

At times, there seemed to be an attitude of deference, in that if the outsider was using it they must have had some purpose for doing so.

> The muzungu was using it so most likely it was effective - *Casual Worker 13*

> A white man *[Author Note: Non-Africans who are not black or brown are often referred to as "white". The operators were in fact Japanese.]* had it on the farm, it was moving in the farm being controlled by a remote, I don't know what it was for - *Casual Worker 3*

In the community, some participants expressed that the drone was probably not intended for Rwandans, and that:

> Only an Indian who has a sugar plantation might need it - *Community Farmers 3*

Part of the line of inquiry that the participants had for us – we later realized – was about whether or not the building and operating of drones will be done in Rwanda.

> When will this be implemented in our area? Are the drones assembled in Rwanda or imported? - *Community Members 4*

> Will there be jobs that come out of these drones being implemented? - *Community Members 8*

Along these lines the participants asked a lot of questions about who controls the drones and if they will be able to control them and who will own them.

> Okay, but am worried about how drones can communicate with me. Are the instructions from the drone in English, Kinyarwanda, or French? - *Community Farmers 5*

> How do you control the drones? [...] who owns drones, individuals or companies, or only the government? - *Community Farmers 6*

4.3.2 What is the Cost and Can we Repair it? Participants' process for figuring out if the drones would provide any real benefit to them, was influenced by the initial cost and the cost of repair. Many participants had knowledge about what can happen if repair of these technologies to support work is too expensive, due to their experience with other technologies (e.g., tractors, mobile phones). These questions were asked across all stakeholder groups, there was a clear national/cultural identity where stakeholders were openly wondering about how their fellow Rwandans would afford and benefit from the drones.

> These drones are coming, how will every person benefit? What will the cost be for a local person? - *Community Members 7*

> How long will the project last, will it be implemented in Rwanda will it help young farmers in Rwanda? Young farmers don't have money, how will they afford drones? - *Staff 4*

> I can see, while searching some information on the internet, that those devices [points to UAV, UVG] they are a bit expensive, rural farmers, apart from the companies, how this project will support the interested farmers to have such devices? - *Staff 3*

In addition to the concern about affordability, participants were concerned with the cost and feasibility of repairing the drones once they fail.

> The challenge is that some stuff, that people have very knowledge about using these, when it's broken down it's easy to get the spare parts. - *Staff 1*

> It can easily get spoiled and no one can repair it. - *Community Farmers 5*

> Its spare parts should be easily available here in Rwanda - *Community Farmers 6*

> Are there spare parts for drones? Why don't we fly it? - *Community Members 3*

> What is the price of drones, can us farmers get them easily? When implementation starts, will there be a company that makes them in Kigali, where we can get spare parts? Won't the repair cost of a drone be even more expensive than a drone, if spare parts come from abroad? - *Community Members 11*

5 DISCUSSION

In the above we present findings from our formative investigation of a developing drone assemblage in Rwanda. We interact with a wide range of stakeholders, evoking imaginaries, both positive and negative. The imaginaries reflect states of mind and expectations of a wide range of stakeholders. This helped us to uncover and reflect on the consequences and attitudes of not only the users and non-users on the farm, but also the community in which this assemblage would operate. There are several themes that we want to call attention to and discuss in this section.

5.1 Imaginaries from a Wider Set of Stakeholders

Our research finds imaginaries are heterogeneous, both across and within stakeholder groups. This is a complement to the notion of 'collective imaginaries' emphasized in previous research, which might be an artifact of data being drawn from technology workers and elites [41, 44]. In

contrast, our findings are in line with Felt's, who observed differences in imaginaries related to individuals' health information-seeking behaviors and their implications for their relationships with their doctors [22].

In addition to the range of stakeholders, the heterogeneity of imaginaries may be related to different positions of power, as reflected in agency (or a lack thereof) over the technology. When participants of evaluations had a higher degree of agency, e.g., they were all part of developer and policy stakeholder groups [41, 44], a greater emphasis is placed on the more homogeneous 'collective imaginaries'. Whereas, when the participants were part of a group that had less agency, e.g. a group of IT-users rather than developers, a greater emphasis on heterogeneity is seen [22].

Our participants had different relationships to the technology. Some saw it as a tool that they would be using in the near future, some saw it as displacing their job, and others were mere observers with a lack of more personal investment, who would not be immediately impacted by its deployment. In some cases, poignant concerns were expressed, together with a lack of agency. As partners, these stakeholder concerns should be addressed in design, through policy-making, in government programs, or all three.

Perhaps due to non-use or people subjected to use, our research finds 'anxious' imaginaries, both related to individual concerns, as well as concerns for others (e.g. poorer farmers). In contrast, research with users from more privileged positions found imaginaries associated with users' status attainment. Specifically, Lindtner et al.'s case study of a technology-based gaming club, found participants differentiated their technology use from that of Internet cafes [41]. Club members were elites and their particular use of technology co-mingled with their enactment of status. Our very different sample of community members and farm workers also indirectly recognized the status and benefits technology use creates, but did so in relation to expressed concern for poorer farmers. As explained by Winschiers and Bidwell in their Afro-Centric HCI paradigm, the African concept of Ubuntu or humanity, reflects the theme of African communalism [63]. As such, expression of concern for others is likely to play a greater role in expectations of technology and its societal impact than one might expect from a Western perspective.

From a policy perspective, these concerns can be associated with the 'public good.' Wong and Jackson link imaginaries to notions of public goods and here we provide evidence of this role among stakeholders [64]. Involving more diverse stakeholders, particularly stakeholders only indirectly impacted by technology, much earlier in the design process, should help to highlight some (admittedly not all) of the negative consequences that stakeholders sometimes suffer (e.g., Usees [7]) beforehand.

5.2 Importance of Historical/Social Context

A benefit of interrogating this wider set of stakeholders, is that we got a more full and rich appreciation for the context in which this technology was being deployed. This lends further evidence of the role of past and current technologies in participants' constructing of imaginaries. Wong and Jackson [64] identify the role prior and existing technologies play in shaping current sociotechnical imaginings. They note that current imaginaries are "built upon and constrained by the technical, regulatory, and cultural legacies of the past." Similarly, Lindtner et al. [41] describe a co-working space in Shanghai as aligning its work with Chinese values of modernization, as well as Western notions of an open and free Internet. They also point to ideas and work ethics from the past and other places in shaping current technology practice. The Rwandan government alignment of drones with aspirations for societal advancement, has in some cases generated positive imaginaries. This finding complements Kumar et al.'s recognition of the embeddedness and potential for collective aspirations related to technology [39]. However, to date, the emerging aspirations-for-design literature speaks only to the positive implications of technology, neglecting

fears (well-founded or otherwise) and their implications for aspirations. Our analysis, particularly in capturing previous negative experience with technology, creates paths for 'design to mitigate potential harms.'

In our case, our work demonstrates that even experience with technologies that are ostensibly unrelated to IT (e.g., a farm tractor or cultural aspirations) can influence fears and desires for new technologies. As such, developers of workplace-specific tools should consider a broader range of influences on concerns and hopes within that culture.

5.3 Agency over Direction of Technology

As part of understanding this historical and social context that we engaged with, it was very clear that our participants and the community that they were part of were interested in agency. This agency was not just about agency in using the technology, but agency over the technology and its future direction. This aspect of our research highlights some of our participants' status as non-users of the technology and the types of agency, more at a community or country level, that they are concerned with. That is, this manifested itself in their concern with how Rwandans would directly benefit from the technology, how repairable the technology was, who was developing the technology, and what happened when something went wrong with the technology. These uncovered perspectives and issues might be hard to address with specific changes to an interface, however, they can serve as design constraints (e.g., how the object is repaired or what languages the interface is available in) or may be useful for organizations/governments (who may not be developing the technology) to understand how to implement policies to mitigate negative impacts of technologies. As part of this, there may be an impact on the feeling of community or cultural agency over a technology when it originates from 'outside' of the culture in which it is being deployed. We saw a clear and justified skepticism around who was behind the technology, to what end the entire assemblage was being deployed, and who it was really meant to benefit.

5.4 Observable vs. Unobservable Functionality

One weakness of our investigation, or at least something that struck us in hindsight, were the aspects of the assemblage that participants did not mention. For example, the more professional farm staff were not concerned that their jobs might be impacted and generally, stakeholders were not concerned with the data that was being extracted from their community (that is, while they were concerned with privacy, they were not concerned with value). Upon reflection, we realized that this was likely because only observable features (e.g., a camera) connect to imaginaries. This seems to be a deeper problem to us than the some of the current conversations around algorithmic transparency, in that, if the functionality is not even observable it is an even deeper problem than opaque functionality that users are aware of (e.g., assignment of jobs in Uber or news feeds on Facebook).

We see this extraction of data as almost a return to colonialism. That is, the jobs that are created by this data are far removed from the extraction site and the value is extracted alongside the data. In the case of the drones, they are extracting data to construct models for better crop utilization or for better navigation of these types of terrain and conditions, which will give them a competitive advantage in the same markets.

Therefore, while plans for ongoing data transfers from the farm are uncertain, the same is not true of Zipline, which is in full commercial operation. As we learned on a visit to Zipline's local operations, its observable and short-term product is delivery of medical supplies. However, following each flight, data are automatically downloaded and transported to headquarters in the United States. The flight and environmental data (e.g., air pressure, wind speed) provide the basis for further software development. These analyses improve delivery service in Rwanda, but also

provide value to the firm and support its ambitions for broader international deployment. So, while Zipline does employ Rwandans in its launch facilities, it is true that the highest value work of algorithm development, is conducted abroad.

In terms of using imaginaries, this the lack of concern over data extraction may be due to the invisibility of those functionalities. The emphasis of much of the current discourse on drones in Rwanda and drones in agriculture focuses on the physical and hence more visible functions (e.g., delivery blood supplies, spraying pesticides). However, the invisibility of functions has not hindered development of imaginaries in other realms. For instance, Lustig's [44] analysis of blockchain, as well as her historical discussion of imaginaries of autonomous (largely invisible) systems, suggest visibility is not required. However, it may be the case that those imaginaries were formed by participants more familiar with the specific technology in question and its capacities. As such, research engaging a wider variety of stakeholders may need to consider the (in)visibility of features in assessing imaginaries.

5.5 Uncovering Design Consequences and Constraints

In this paper, we have outlined findings around some of the anticipated uses and impacts of a agricultural drone assemblage. While there are certainly design lessons to be learned from our study, we see a potential danger in framing the results of this study as simply 'design implications'. This is because, if we look at these findings solely through the lens of product development and use the metrics of adoption and deployment to determine level of success, the outcomes might be to capitalize on unobservable design or to make more persuasive designs that work around the perceptions and attitudes of the target population. Instead, we frame these findings more in terms of the interests of our participants, so that we are uncovering the potential consequences of deploying a technology and imagining what types of design constraints are needed to mitigate these consequences – whether through policy or otherwise.

Using this lens, we see several constraints that could be put on the design of the technology arising from our interactions with stakeholders. For instance: the need to design such that the devices can be repaired by locals; supporting openness (e.g., documented APIs) to enable local innovation/configurations so that locals have agency over the direction and the use of the technology; ensure that data systems are not exclusively autonomous or invisible; clear manual overrides and use of local languages; and even clear branding or indicators of who owns the device. We see these not as implications for design necessarily, but constraints that organizations can put on technologies so that the deployment of these technologies can be considered a success to a wider range of stakeholders, in particular the local stakeholders whose community is where much of the value originates.

Translating this into policy, means that policymakers might consider public information that encourages the agency of the general public in relation to drones. Issues of empowerment and concerns for the public good, and in particular marginalized populations (poor farmers) should be taken into account. Similar to imaginaries drawing on historical experience with technology, policymakers might examine historical approaches to agricultural technology policy and the lessons learned in devising polices that will promote equitable access to and use of drone technologies across the sector. This is all couched by the fact that economic development in the Global South always has to contend with attracting and managing foreign investment. Data extraction is now a part of that process. But similar to processes of controlling and managing natural resources, attention should paid to international data flows through multinationals. Such monitoring could be woven into Rwanda's emerging National Data Revolution Policy [1].

6 LIMITATIONS AND FUTURE WORK

In our analysis there is room for more nuanced analysis of the data in terms of the differences in imaginaries between aspects such as gender, education levels, or fluency with technology. Furthermore, it would be interesting if future protocols around imaginaries in Africa engaged more with how introducing ideas of Afrofuturism might change the nature of these imaginaries to provide avenues to imagine more empowered futures of technologies within these communities. Additionally, we realized in analysis that the physical interactions and video about how these drones would be implemented had implicit educational functions, and in this way provided benefit to participants who were not already knowledgeable about them. Future research should endeavor further education, particularly if it this eduction would support greater agency.

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