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Situating the social sciences in responsible innovation in the global south: the case of gene drive mosquitoes

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ABSTRACT

There has been growing attention in recent years on the potential reconfiguration of responsible innovation (RI) to increase its relevance for global challenges in the Global South. This reconfiguration will require a broad and empowered role for social scientists. Yet RI has been preoccupied with public and stakeholder inclusion, rather than social science inclusion. We probe this gap through a case study of the social sciences in the development of gene drive mosquitoes for malaria control in Mali and Uganda. Our data reveals potential diverse roles and future research agendas for the social sciences. We outline some challenges facing the social sciences in this space and ways to promote and support them. Lastly, we argue that RI's predilection for reflexive and critical social science obscures a richer repertoire of social science roles that are an imperative and fundamental part of efforts to address global challenges in the Global South.

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The social sciences and responsible innovation in the global south

In 2020, the World Health Organisation announced 13 urgent and interlinked global health challenges for the decade ahead (WHO 2021). These include climate change, the spread of infectious diseases and the delivery of health under conditions of conflict and crisis. Such global health challenges disproportionately affect low and middle-income countries in the Global South (Chu et al. 2014; Lambert et al. 2020). Following the Lund Declaration of 2009 and high-profile support from the European Commission, responsible innovation (RI) has come to be recognised as a prominent innovation discourse focused on the collective stewardship or steering of innovation trajectories to address pressing societal challenges in ways that are aligned with societal values. Despite the predominance of societal challenges in the Global South, RI has continued to exhibit a Northern-centrism with case studies and theory building drawing predominantly on examples from the Global North. This misalignment has led to increasing calls for a more 'inclusive' RI framework, one that is attuned to the question of how RI might

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work in specific political, social, economic and structural contexts in the Global South, and one in which the very process of theory building for RI is made more robust through learning from innovation orientations, processes, insights and practices taking place in different parts of the world. Recent studies have subsequently sought to examine RI in the Global South (de Campos et al. 2017; de Hoop, Pols, and Romijn 2016; Hartley et al. 2019; Macnaghten et al. 2014; Pandey et al. 2020; Wakunuma et al. 2021), compare RI in Global North and South contexts and consider how RI might work effectively in the Global South (Hartley et al. 2019; Vasen 2017; Wakunuma et al. 2021). Others have explored the value of experiences with RI in the Global South for theory development (Pandey et al. 2020; Valkenburg 2020), pointing to the importance of avoiding assumptions about knowledge, power and development. As Macnaghten et al. (2014, 193) argue:

> RI in its Northern constitution has a normative basis that advocates for a 'different socio-technical order to be', one that 'hints at a more inclusive, democratic and equitable science – society relationship' (van Oudheusden 2014, 72). But from a Southern perspective (notwithstanding the large heterogeneity that characterizes its countries, regions, municipalities and institutions) Northern assumptions of what that socio-technical order and those science – society relationships are (or should be) are at best naïve.

In this paper we respond to these calls and critiques, examining the positioning of the social sciences, as defined by actors in the Global South, within the context of an innovation assemblage intended to address a pressing global health challenge in sub – Saharan Africa – gene drive mosquitoes for malaria control. Chief Executive of the British Academy, Hetan Shah (2020, 295), recently argued that without engaging social science expertise, governments will 'fail to tackle the challenges of this decade.' The social sciences can redefine problems, interrogate assumptions, open up new questions, provide critical thinking, help to understand processes, and work towards more equitable and sustainable innovation futures. This notion of 'opening up' is a fundamental tenet of RI practice and in related cases of biotechnology and nanotechnology in the Global North, social scientists have demonstrated that what matters to publics are not simply the risks associated with these innovations, but creating space to both address and negotiate more fundamental questions such as who owns it, who benefits from it and to what ends will it be directed (Hartley et al. 2021; Marris 2015; Sarewitz 2015; Wilsdon and Willis 2004). Social science contributions have also been integral in understanding why and how innovations (such as diagnostic tests for related and pressing societal challenges such as antimicrobial resistance) can generate unintended consequences and on a practical level how publics can be brought together in ways that are culturally relevant and cognisant of specific power relations and dynamics (de Hoop, Pols, and Romijn 2016).

In spite of the value of the social sciences in helping to 'open up' innovation trajectories and pathways, Koch (2020) and Valkenburg et al. (2020) emphasise that RI has too often been preoccupied with the inclusion of communities, stakeholders, and publics, rather than looking at epistemic inclusion with regards to the structures of science itself including the social sciences. RI's predominant focus on the inclusion of publics and stakeholders, can marginalise social science scholars and exclude them from participating in knowledge production (Koch 2020). In the Global North, research suggests that social scientists are often channelled into a 'handmaiden' role in

collaborative spaces of biotechnology development, designed to facilitate the scientific or technological innovation in hand (Balmer et al. 2015). Other research shows how the natural sciences dominate global debates about emerging technology with little input from the social sciences (de Graeff et al. 2019). There has, to date, been little empirically informed delineation or agenda setting surrounding the role of the social sciences in innovation assemblages in the Global South. Amidst the recognition that RI predominantly speaks to European priorities, values and concerns (Macnaghten et al. 2014; Valkenburg 2020), there are growing calls to critically consider the 'transduction' of RI from Europe and North America to the Global South (Doezema et al. 2019). Transduction is positioned not as the imposition of European norms, but as a generative space of encounter where engagement with the questions RI inspires in non-European spaces may shape future innovation practices and institutional arrangements (Doezema et al. 2019).

Global South scholars are heavily marginalised in knowledge production (Mouton 2010). Yet, we know that such scholars are essential for addressing the region's development challenges (Owusu, Kalipeni, and Kiiru 2014), particularly with regard to innovations that are sustainable, novel, appropriate and can generate ownership within the region. Too often, natural scientists from the Global North define social science contributions in the Global South in terms of delivering community acceptance of innovation through public engagement. For example, the Entomological Society of America (ESA 2020, 487) states, '*It is the responsibility of scientists to ensure communities are consulted by trained professionals (i.e. social scientists) about [gene drive technology] for specific applications. Community engagement early and often should make [gene drive technology] development a team effort between natural and social scientists working together with local communities.*' However, the reconfiguration of RI needed for addressing global challenges in the Global South, will require a richer, broader, and more empowered role for social scientists and RI's focus on inclusion suggests Global South scholars should be involved in these efforts.

We examine this requirement through the case of gene drive mosquitoes in Sub-Saharan Africa. The first field trials of gene drive mosquitoes are likely to take place in about 5 years in Uganda, Mali or Burkina Faso and the gene drive community is committed to the responsible development, testing and governance of gene drive (AUDA and NEPAD 2018; Hartley et al. 2019; James and Tountas 2018; Ledingham and Hartley 2021; Long et al. 2020). The technology has high level political support, with the African Union's High-Level Panel on Emerging Technologies identifying gene drive mosquitoes as a priority technology for malaria elimination (AU and NEPAD 2018). Ugandan scientists and stakeholders hope that gene drive mosquitoes may reduce the huge burden of malaria (Hartley et al. 2021). Powerful calls have been made from within Africa for equitable research collaborations and partnerships to shape gene drive research and its governance, with African actors, including social scientists, arguing that African voices must become more part of the conversation (Kamwi 2016; Pare Toe 2021). For example, Pare Toe (2021) shows how social scientists can explain societal responses to technology through understanding political, economic or cultural issues and facilitate co-development of gene drive mosquitoes, evidencing how stakeholder knowledge about potential risks contributed to the technology's development and garnered support for evidence-based scientific solutions to malaria control. Despite such examples, there has been little examination of the role of the African

social sciences, with significant assumptions about their role as community engagement practitioners.

To address this gap, we explore the role of the social sciences in the case of gene drive mosquitoes, their potential for the responsible development of a technological solution to a global challenge, and what this means for the ongoing reconfiguration of RI. We examine how stakeholders in Mali and Uganda perceive the potential contribution of the social sciences to the development, testing and governance of gene drive mosquitoes, and how social scientists and stakeholders in Uganda might define a social science research agenda for gene drive technology. We conducted secondary data analysis on interviews held in Mali and Uganda in 2018 and 2019 and held an exploratory workshop in Uganda in 2021, designed and led by social scientists at Makerere University (CO and SN), to explore the opportunities and challenges facing social science input into gene drive governance. Importantly, this is the first time an agenda for gene drive governance has been defined by social scientists in an African country where gene drives are likely to be trialled.

We find that RI's theoretical predilection in the Global North for critical social science, obscures the nuances and diversity of the roles to be assumed by social science in supporting robust and responsible innovation responses to pressing challenges as defined by actors in the Global South. We argue not simply for 'more' social science but for more critical and granular thought into the positioning of social science contributions in collaborative innovation spaces if they are to meaningfully contribute to global health challenges involving emerging technologies. Social scientists face numerous structural hurdles to involvement, yet without their involvement, RI will be another colonial structure defined elsewhere.

Methods

We conducted secondary data analysis, drawing on interviews conducted in both countries in 2018–2019 and a workshop held in Uganda in 2021. Our data set comprises 35 interview transcripts and a workshop report. The methods for collecting the interview data are described in two previous publications on gene drive governance in Mali and Uganda (Hartley et al. 2021a; Hartley et al. 2021b). The first set of transcripts consist of 16 semi-structured interviews conducted in Mali in 2018 with Target Malaria natural scientists including molecular biologist and entomologist specialists (M1, M5, M6, M9, M16), independent natural scientists (M10, M11), social scientist engagement experts (M2, M3, M4, M8, M15), independent ethics experts (M7, M14), a regulator (M13) and community representative (M12) (ethics approval provided by the University of Exeter Business School eUEBNS001032). These interviews were conducted in French and subsequently transcribed and translated into English. They explored understandings and experiences of co-development – a specific form of co-production accompanying the development of gene drive technology which has appeared in high-level governance documents and the overarching strategy documents of the Target Malaria Consortium (Hartley et al. 2021a). The second set of transcripts consisted of 19 semi-structured interviews in Uganda with Target Malaria natural scientists (U1, U3, U4, U18), independent natural scientists across the domains of biotechnology, health and veterinary sciences, environment and entomology (U6, U7, U19, U11, U12, U13, U15), a social science

engagement specialist (U2), independent legal expert (U10), regulators including impact assessment and regulation experts (U5, U9, U14, U16) and community representatives (U8, U17). CO conducted the interviews in 2019 and explored participants' hopes and concerns associated with the development of gene drive mosquitoes, as well as who should be involved in the risk assessment process and identification of harms (Hartley et al. 2021b) (ethics approval provided by the Uganda National Council for Science and Technology SS5059 and Makerere University Social Sciences Research and Ethics Committee MAKSS REC 05.19.300).

The workshop methods can be found in the workshop report (Opesen 2021). CO and SN, social scientists based at Makerere University in Uganda, designed and hosted the hybrid (physical and virtual) workshop in May 2021 at the Kampala Kolping Hotel entitled 'A Social Science Agenda for Gene Drive Research'. Participants included social scientists from Makerere University and Gulu University in Uganda, members of Target Malaria Uganda, regulators from the Uganda National Council of Science and Technology, the National Bio-safety Committee, district local governments and Advocates Coalition for Development and Environment (ACODE), an independent public policy research and advocacy Think Tank. SH participated online. The workshop sought to better understand the challenges facing both malaria control and the development of gene drive as a potential tool to address it. The workshop's goal was to develop an agenda for social science research on gene drive governance in Uganda. Data analysis proceeded thematically (Braun and Clarke 2019) and inductive coding was undertaken collaboratively by KL and CO. Emergent themes were organised by: (a) mapping the social context or milieu within which gene drive research and development is taking place in Mali and Uganda; (b) the role of the social sciences in gene drive in Mali and Uganda; and, (c) social science agendas for gene drive as defined by Ugandan social scientists and stakeholders. Themes and arguments were discussed in conjunction with the whole authorship team.

Social sciences in responsible gene drive governance in Mali and Uganda

Mali and Uganda carry a high share of the global malaria burden (WHO 2021). Malaria is the leading cause of death in these countries and continues to exert a devastating impact on communities and local economies (WHO 2021). It is both a driver and manifestation of poverty and inequality (Bardosh 2014). Efforts to prevent malaria transmission include residual spraying with insecticide and the distribution of long-lasting insecticide treated bed nets. Management efforts are thwarted by the development of insecticide resistance and institutional reaffirmations to eliminate malaria have contributed to interest in the development of new innovative solutions to tackling this pressing challenge issue. It is within this context that Target Malaria, a large international research consortium with funding from the Bill and Melinda Gates Foundation (BMGF) and the Open Philanthropy Project, is developing gene drive technology to be used on the *Anopheles gambiae* mosquito as a tool of malaria control and/or elimination.

Target Malaria is modifying the genome of the mosquito through two strategies: reducing female fertility and 'sex-biasing' where all offspring will be males. These modifications are accompanied by a genetic drive mechanism, meaning that there is an up to 99% chance that the genetic modification will be passed on to all offspring. Malian

and Ugandan natural scientists from the Ugandan Virus Research Institute (Uganda) and the Malaria Research and Training Center at the Université des Sciences, des Techniques et des Technologies de Bamako (Mali) are part of Target Malaria and active in the technology's development and preparatory activities for the possible field trial of gene drive mosquitoes. Gene drive technology is intended to persist and perpetuate in the environment, and work is also underway to assess potential social and ecological impacts. No gene drive organisms have yet been released in the wild and the release of these mosquitoes in Uganda, Mali and/or Burkina Faso is expected to be the world's first.

Although a signatory to the Convention on Biological Diversity and the Cartagena Protocol on Biosafety, Uganda has no specific legislation capable of regulating gene drive mosquitoes. The government has drafted a Genetic Engineering Regulatory Bill (2019) that will cover gene drive organisms. However, the Bill is contentious and President Museveni has twice returned the Bill to Parliament citing concerns about safeguarding citizens and ecosystems (Museveni 2019). When Target Malaria is ready for field trials, it will likely need approval first from the National Environmental Management Authority (NEMA) and then by the Uganda Virus Research Institute Biosafety Committee, National Biosafety Committee (NBC) at the Ugandan National Council for Science and Technology (UNCST) and the National Bio-Ethics Committee at the Ministry of Science, Technology and Innovation. This approval process will be managed by the competent authority which is likely to be UNCST. Until the Bill is passed into law, gene drive mosquito field trails cannot progress to open field release.

Global North philanthropists are powerful actors in Mali and Uganda, providing significant amounts of funding to build harmonised legislative and regulatory frameworks across sub-Saharan Africa and ensure that existing institutions, stakeholders, and communities accept and deploy gene drive mosquitoes (Hartley, Kokotovich, and McCalman 2022). For example, both the BMGF and Open Philanthropy Project have provided millions of US dollars to public relations firms and development agencies to support the evaluation, preparation, and potential deployment of gene drive technologies (BMGF 2020; Open Philanthropy 2020). These investments dovetail into the broader regional context where the African Union views science and technology as a cornerstone of Africa's much-needed socio-economic transformation (AUDA-NEPAD 2020).

Section 3.1 outlines the case of gene drive mosquitoes and the social dynamics that intersect with the technology's development in Mali and Uganda, highlighting key themes emerging from the data. These social dynamics demonstrate the need for diverse and broad social science research. Section 3.2 presents four dominant existing roles the social sciences play in this case and Section 3.3 outlines the future research agenda identified by Ugandan social scientists, reflecting the social dynamics of the case, and expanding the existing roles for the social sciences in gene drive technology development.

The social dynamics of gene drive and the need for social science research

The data highlights a broad range of issues participants identified that are ripe for social science investigation. These issues sit in the broader social context or dynamics of gene drive technology development. All participants identified malaria as a pressing global challenge and many of them raised concerns about potential ***social scepticism towards***

gene drive technology. Indeed, Hartley et al. (2021) found Ugandan stakeholders had a strong desire for gene drive mosquitoes to work and saw a lack of public and political support as a significant risk. Our respondents stressed, for example, that 'people can be sceptical of new technology' (M1-3). This was perceived to be exacerbated by prior experiences such as 'colonial bombardments of DDT where no one was given the right to ask why this was happening' (M7). These experiences were described as a 'reason not to want biotech' (U4), and that without appropriate community involvement, community members 'may think we want to poison them or spread new illnesses' (M7). Interviewees voiced concerns surrounding the importation of mosquitoes: 'they may think we are going to import Malaysian mosquitoes and cause another plague' (M7), with scepticism amplified by the perceived experimental nature of the technology. Interviewee M9 stressed that 'I would prefer these things do not start directly in Mali because we do not yet know the contours. It's an experimental research.' Interviewee U6 relatedly posited, 'are we some kind of guinea pigs?' There was a sense that 'even among scientists, not many scientists know it' (U18) and that 'people feel that maybe the research is being imposed on a country without sufficient time to understand the benefits' (U16). Connections were made to BT cotton, with U10 emphasising 'there's a lot of scepticism [surrounding] these GMOs to deliver the promises they say, the commercialised results are not as good as claimed.' M13 similarly described how 'after a few years of using BT cotton, [people] began to notice a reduction in the size of cotton bolls and eventually that overtook GM BT.' There was a clear sense that unless the technology is robustly adapted to the African context, 'it will be like other technologies which were imported, which came to us form overseas, which cause problems after they arrived' (M13). U10 remarked how 'there are other African countries that have eradicated malaria without the need for technofixes … we need to learn from them and extrapolate lessons' (U10) and participants questioned whether the 'benefit especially commercially will necessarily be shared fairly' (U16).

As well as being accompanied by a strong sense of social scepticism, it also became clear through our interviews that gene drive technology is being developed in Mali and Uganda amidst ***challenging structural realities.*** Respondents described difficulties of building legislation and regulations under conditions where governments are in flux. M13 emphasised that 'every time I tried to introduce the decree the ministers change three times, there hasn't been a government that has stayed the same for more than 6 months.' M7 relatedly stressed that we must 'establish teams of people which last.' For M9, 'it's not the building or institutions that are lacking it's the people who are changing a lot.' Lack of 'adequate regulation and policy to regulate these technologies' was identified by participants (U7, U10) as a key challenge. 'Brain drain' was relatedly described as a phenomenon where scientists and innovators move to places where legislation is in place. While there was an acknowledgement that in-country expertise does exist, one participant stated that 'what we don't have is actual working regimes' (U15). Regarding the technical dimensions of the technology, U10 stressed that 'I think first we need to understand first generation technologies before gene drives.' U16 similarly stated that 'we have not been sufficient in education and awareness creation so a lot of biotech knowledge is at low levels.' Biotech was described by M5 as being 'far from understood by people' and confused with biopharma. Respondents emphasised that 'many people don't know the malaria life cycle' and that 'some people think malaria comes from milk or mangoes (M9).' Challenges of illiteracy were raised and

M16 described how 'one of the problems is people just don't have the correct information or have information which is just not true.' U14 questioned whether 'now we have released the GM mosquitoes into the environment … do we have capacity to manage the associated potential risks or even the human resources? They are not adequate and above all you need to have a plan of training people because people retire, people leave jobs … how do you then handle it?' This resonates with broader findings and research into the governance of health research in eastern and southern African countries, which have stressed that inadequate financial and human resources capacities continue to undermine the development of strong health research (Juma et al. 2021).

Our data also highlighted the importance of the ***cultural and religious context*** in Mali and Uganda. There was a strong articulation of the importance of social referents – actors and figures trusted and valued by communities. U2 emphasised that 'cultural leaders cannot be underestimated here in Uganda'. U1 similarly stressed that 'if the leaders are negative, even if you go to the communities it wouldn't work.' Religious and cultural leaders were described as being 'listened to,' particularly the Pentecostal Churches (U15). Participants referred to the existence of religious logics, making reference to fatalism and 'God's will' (M9). The 'backing of the Ministry' was also recognised as being an important source of generating legitimacy surrounding the development of new technology (U9). Respondents described a rich repository of African expertise and an 'African based history of engagement with communities' (M1), with M7 expressing that speaking 'Malian dialects is a condition for entering the community' (M7). Traditional communicators were described as important and practicising an 'art form' (M14). M9 expressed a deep understanding of the role of eating with village leaders in building meaningful relations. When asked about the nature of engaging with communities and publics, participants articulated their own ideas about what meaningful and contextually specific engagement practices might look like. For example, M14 emphasised that 'we're not just talking about persuading one person to do a certain thing.' U17 pointed to the importance of the technology developments teams being accessible, with U10 suggesting the involvement of district area MPs.

Understanding the dynamics of the social that intersect with the development of gene drive technology is important for a number of reasons. Recognising the social dynamics that contribute to scepticism can help to move beyond what Bardosh (2014) describes as the 'problematic assumption' that resistance to health initiatives and technologies stems from a lack of awareness, pointing to the importance of sociological and historical understandings. More importantly, however, mapping the social dynamics in this way clearly evidences that the domain of the social cannot be restricted to public opinion alone – a key issue that we explore in sections 3.2 and beyond.

Understanding existing roles for social science

This section identifies four themes that emerged from the data on the role of the social sciences in gene drive development in Mali and Uganda. This role was positioned as being able to (a) deliver acceptance of gene drive technology; (b) enable effective communication; (c) help to understand people and change behaviour; and (d) bring new perspectives to problem definitions and solutions.

Theme 1: Social science delivers acceptance of gene drive technology

The social sciences were understood by our respondents predominantly as facilitating and generating social acceptance. 'Linguists, sociologists and agro-economists' (M13) were described as functioning to 'help smoothen the project and ensure its success' (M13), making 'the difference between emotional areas' (M1). M12 described social scientists as the 'needles that sew everything together … that's the work of the sociologists.' For interview participant M9, 'when the social anthropologist agents go to these areas and sites, there are actions that they take to help the people there accept scientific progress.' As M9 further explained, 'people like specific smells … and colour … we need social anthropologists to lead people to accept our actions.' It was emphasised by M9 that 'if we can't use them [social scientists], we won't see the results that we want.' For U1, 'cultural leaders are like social scientists. Like we see now in Buganda, if the Katikkiro said something, let's say he is against the GMOs, can you succeed doing any work here? You can't. But supposing he supports? Work would be easier for us.' M7 described social-anthropologists as the 'spies of medicine,' helping to remove potential hurdles to the development of the technology. U2 emphasised that 'we have the regulators, of course we have the cultural leaders, political leaders, we have the academics, we have the civil society, all these speak for and support this kind of research, and all of them have a sphere influence that we need.'

Theme 2: Social science enables effective communication

Related to the theme of social acceptance was a strong emphasis on the practical dimensions of informing, explaining and educating communities. The 'skills of sociologists, agro-economists, [and] traditional communicators' were described as being imperative in 'making the community understand the comparative advantages' and 'explaining in the finest detail' (M13). As M5 put it, 'they help people understand the technologies.' For M11, 'sociologists and people from the communities themselves, are the people to inform first and foremost.' M2 emphasised that 'research does not necessarily mean only research into the area of biotechnology. There are different areas of research such as health, language and culture. We need all these different layers to explain what we are doing'. Communication was framed in both instrumental as well as non-instrumental registers, sometimes in terms of pushing towards acceptance but also in terms of raising awareness. On a more instrumental level, M12 described sociologists as being able to find 'the precise word that might be able to appease a situation'. U17 relatedly emphasised that 'if you get a person who is not a good communicator, you spoil the message … so social people that are local bring out these things' (U17). M6 stressed that 'there needs to be a really strong policy of communication. Social sciences have their place here and that is key. Tomorrow, we might have transgenic mosquitoes, but without communication it is nothing.' M9 pointed to the importance of careful and tailored communication, remarking that 'do you know that if people cleaned their yards they would suffer less from insects … we must tell them this, but not in an overly shocking way – Malians do not like instructions.' M7 described how 'Professor [anonymised] … who is an anthropologist … says to us that we speak several Malian languages and dialects, and that those are the conditions for entering

into the community.' For M11 the 'sociologist role is very important' in raising 'awareness about the role of biotechnology throughout the community. Raising awareness is partly about publicity, explaining different products, what they contain, what they do.' U5 similarly stressed that 'I am happy that people in anthropology and social sciences try and break down this technology.'

Theme 3: Social science can understand people and change behaviours

There was a strong recognition of the role of the social sciences in understanding people and behaviours. As M5 remarked, 'social sciences help scientists understand people.' Interviewee M6, described how if the gene drive technique works well, unanticipated or undesired behavioural changes could emerge surrounding the use of protective nets. M6 stressed that 'mosquito nets are not only for protection against malaria … this is where we see the importance of the social sciences. We will need to continue to protect ourselves against other harmful insects.' U3 relatedly emphasised that preempting 'how [people] think, that's sociology.' As M9 explained, 'sociologists are needed here when people say that they do not like the colour of a specific net, or when they say that mosquito nets make them sterile.' U1 placed significant emphasis on the mediating role of cultural dynamics and leaders, stating that 'when government and politicians call people to give blood, [people] don't go there. But when the Kabaka or Katikkiro (prime minister) says we need blood … The whole compound is flooded with people.' M9 similarly stressed the importance of leadership as a key 'sociological parameter.' Social scientists were positioned as understanding the value such stakeholders can bring into the dynamics and will ensure a platform is given to them to play this role.

Theme 4: Social sciences can bring new and valuable perspectives to problem definitions and solutions

A further area where the social sciences were identified as having an important role to play was in relation to the broader impacts of the technology as well as the identification of benefits and harms. U2 stated there is a need for 'social scientists that will be able to bring out the social, cultural, economic impacts.' For U2, the newness of the technology heightened the need for a multidisciplinary approach: 'being a new field we cannot have a limit but rather the opposite, as to who is best placed to make an assessment of an identified risk and we need to have people looking at it from various perspectives, because from the health perspective a risk might be different or might work out differently from a social perspective or a cultural perspective.' U10 similarly stated that 'We need a multidisciplinary committee or team that is going to regulate these technologies in the country and not just it being a scientific issue. Because, as you know, this issue of gene drive is not just about science, it's about human rights, it's about social cultural aspects. There are various dimensions of the implications of this research to us, as Africans, as Ugandans.' Social science was recognised for its role in identifying issues and topics that would otherwise remain unconsidered. For example, M16 posited that 'often that's the problem with some research; scientists are developing things in units and groups and they all share the same mindset and target, and they may think, for

example, that they don't really need to have social scientists who might have another vision.' U4 emphasised that 'you have to lay out what the problem is … but we've come in from the top and now all that comes is this conspiracy thing.' U10 described an 'oligopoly where people with same interests want to regulate without due regard for people on the receiving end … as I already told you, at the beginning of the adoption of this project, they only spoke to researchers in the development of this new technology. They thought that it was only the researchers that they needed. But they really needed a widened sphere of people to help.'

Despite a dominant focus on the role of social sciences as facilitators and generators of social acceptance, there exist multiple framings of social science contributions in Uganda and Mail. The four themes reflect well the social dynamics identified in Section 3.1 and demonstrate the potential for the social sciences in this case. Section 3.3 now explores possible research agendas for the social sciences.

Imagining future roles for social sciences

In the 2021 workshop, participants reflected on their experiences, setting an agenda for social science research, as well as identifying priority areas and research questions not yet being asked. Similar to the interview materials, participants recounted the entangling of gene drive with suspicion, with many people, especially politicians, not trusting gene drives. This was partly used to explain why the bill to regulate field trials was rejected. Knowledge of gene drive was also identified as being limited to a small section of scientists, with even those who are more acquainted, having scant information and mistaking it for GMOs. Participants made a case for social science research independent of the science and scientific research funders from the Global North, emphasising that social science looks at protecting human beings, offering imagination beyond science. Unanimously, participants agreed that most if not all social science disciplines should be involved including social work, anthropology, sociology, gender studies, and political science.

Research priorities identified by workshop participants included a need to explore what people think of gene drive, with concerns being raised regarding the possibility of gene drive being misunderstood at the community level because gene drive is not translated into the local languages. Social scientists were positioned here as being able to support local vocabulary or language development, as well as develop assistive tools including visual aids, which could help to simplify knowledge and understandings of what gene drive is to target communities. This included being able to say gene drive in Luganda, Luo or in Runyankore Rukiga, culturally accepted languages that people can understand. Other priority research areas identified by workshop participants included examining preparedness for unintended consequences, cost effectiveness of the technology, appropriate societal mechanisms for whistle blowing, and the roles to be assumed by target communities. Related to the engagement of target communities, attention was drawn to the need to explore consent models (with a particular alertness to bottom-up design and gender dimensions), as well as any moral, ethical, legal and economic questions in the event that the mosquitoes are patented. Other areas for social science attention included providing explanations on the cultural dynamics that might negatively impact on the gene drive studies and informing risk assessments by interrogating social issues.

As a regional technology which requires regional governance, it was emphasised that Ugandan social scientists can collaborate with those in other African countries to develop a regional agenda for social science research on gene drive in three main ways, namely through jointly developed networks, exploiting and involving the regional East African Community inter-university collaboration framework, and leveraging the NEPAD platform at the continental level. Participants pointed to an overreliance on international regulations, calling for attention to the pathways to engage with the relevant legislative bodies and create awareness following properly laid down procedures and structures. Similar issues and priorities have been identified in analyses of the factors necessary to support robust health governance systems in Africa, a key area of interest and attention for the WHO Regional Office for Africa (Juma et al. 2021). Workshop participants envisaged connections with the village health teams (VHTs) and district vector control officers. It was emphasised that there is a need for the social sciences to clarify different cultures and philosophies of risks and benefits associated with gene drive, as well as the role of indigenous knowledge in the design of governance frameworks. Lastly, they identified a need to enhance participatory approaches and interdisciplinarity to include both communities and stakeholders, as well as social scientists in technology development and governance.

The workshop was a first step in enabling social scientists and stakeholders to reflect on the social dynamics of malaria and the potential of a gene drive solution. It enabled discussion of future roles for the social sciences imagined in relation to the governance of gene drive in Mali and Uganda which cut across a range of communication, critical, generative and descriptive modalities of social science.

Opening up responsible innovation to social sciences in the global south

In the 2010 World Social Science Report, Mouton identified that the social sciences are practiced within most African countries in universities operating under conditions of significant under-resourcing, where state funding is an exception rather than the rule (Mouton 2010). Mouton identifies patterns in the practice of social science across the continent, describing little mention of social science in National African research plans, with an overarching emphasis focusing on the health sciences, and 'popular' priorities such as biotechnology. More recently, there have been flickerings of shifting dynamics. In particular, the Ebola epidemic of 2014-2015, marked a pivotal moment in global health where social science and humanities expertise successfully 'cut into the dominant paradigm of biomedicine and health science that currently undergirds global health' (Holden and Jensen 2017, 124). Social scientists were able to articulate the social-cultural dynamics in tension with science-led responses and were provided with a level of access to decision making platforms and bodies (Abramowitz et al. 2015). This situation was also observed in the Ebola Sudan Virus outbreak 2022 in Uganda. Here, social scientists effectively 'humanised' the response, feeding into the development of effective risk communication and community engagement strategies seeking to ensure resonance with communities on the ground. Social science data has also contributed to the identification of gaps and concerns relevant to the design of a more robust response, including concerns associated with the militarisation of the response, the lack of traditional healer involvement, the belief that ebola was 'good

business' and for political gain, the ways in which colours and presentational materials fuelled this belief further, anxieties associated with the large and flashy nature of the vehicles associated with surveillance initiatives and distrust in the medical profession (Bardosh, Gercama, and Bedford 2019). Anthropologists and community engagement officers have further played a role in negotiating safe burial practices (Anoko and Henry 2020) and as Allgaier and Svalastog (2015, 498) have more broadly stressed, the 'biomedical concept of contagion, … can strongly differ from the complex cultural conceptions of contagion in various Non-Western cultures,' providing a clear reminder of the fundamental importance of social science lenses and perspectives.

Diversifying roles for social sciences in responsible innovation

RI and science and technology studies scholars have cautioned against social science roles in innovation assemblages which serve a handmaiden role to pre-defined technological solutions (Balmer et al. 2015; Bardosh 2014). Handmaiden or instrumental roles have been implicated in shutting down opportunities for meaningful opening up of the directionality of technology futures as well as for delimiting the scope of upstream problem definition. In the case of gene drive for malaria control in Mali and Uganda, an instrumental framing of social inquiry also exists in the Global South (Ledingham and Hartley 2021). Social inquiry is formatted in an enabling role by our interview participants, servicing the development of gene drive technology. Social scientists were described as 'communicators' working towards the acceptance of gene technology. This resonates with Mouton's analysis of the state of the social sciences in sub-Saharan Africa, which has emphasised that where 'reference is made to the social sciences and humanities this is usually done as an 'appendix' and in support of or as service to the natural sciences' (Mouton 2010, 34). In RI's Northern framing, the instrumental rendering of social science is closely linked to deficit models of public engagement which holds that resistance to technology is a result of a lack of correct information. Deficit models engage publics tend not to open up innovation trajectories but to smooth out pathways to implementation. They are approaches which have proven 'very difficult to dislodge' (de Saille 2015, 163). Due to the depoliticising role of deficit approaches, RI in the Global North has emphasised instead the richness of knowledges held by multiple publics (Callon 1999) and deficit approaches are regarded as being not aligned with an RI approach (Hartley, Pearce, and Taylor 2017; Macnaghten 2016).

Gene drive development in Mail and Uganda challenges the ready association of instrumental and deficit approaches with processes of depoliticisation. There remain key gaps in knowledge around malaria transmission and biotechnology in need of addressing which raises pressing questions about the need for inclusion of social science activity geared towards an educational dimension, while avoiding the privileging of Western or scientist ontologies which advocate for pre-determined innovation pathways. Indeed, as Pansera and Owen (2018) highlight, science literacy can be an important means of driving empowerment. The tensions and synergies between communicational, educational and critical forms of social science engagement have not yet been fully considered in RI, with RI in the Global North tending towards an emphasis on critical social science. While RI has usefully differentiated between normative, substantive and instrumental rationales for engaging with publics, we suggest that greater differentiation

between various modes of social science engagement is an important area of focus for the RI community going forward. Instead of being necessarily indicative of innovation approaches that are not aligned with an RI approach, these less critical forms of social science can help to redress asymmetries in knowledge and contribute to broader forms of empowerment through raising awareness and contributing to transparency and understanding. More broadly, we suggest that communicational and educational forms of social science may also become increasingly pertinent amidst the development of emergent innovation capabilities in the Global North (such as complex industrial data ecologies) whose scale and distributedness can generate (in)visibilities and render innovations hard to discern, presenting a challenge for apprehension and subsequent collective stewardship. This points to the importance of differentiated forms of social science as an important constituent component of the collective interrogation of technology trajectories, raising implications not just for the theoretical inclinations of RI, but also for how RI is practiced methodologically (i.e. focusing on the pre-figurative work that might need to take place prior to the facilitation of processes of anticipation and reflection).

In this regard, any attempt to develop responsible innovations for contemporary challenges requires making space not only for critical social science, but for social science contributions in all its forms. As evidenced in Table 1 below, there are many forms or modes of social science and while the RI community is particularly alert to the instrumental, reflexive and the generative, to account for only these registers is to miss a much fuller and richer picture surrounding the potential roles of the social sciences in innovation development processes. Bennett's typology below, emerging from the field of conservation environmental sciences, and which we have applied to our case, helps to generate greater reflexivity surrounding the role of the social sciences in collaboration spaces. We suggest that Bennet's framework may help to guide meaningful and generative collaboration practices in the space of RI and that engaging with interdisciplinary sensitivities and tools is an important source of conceptual inspiration and innovation for RI.

Promoting and supporting social sciences in Mali and Uganda

In the Global North there are growing calls for experimental forms of social science collaboration in innovation assemblages and for the cultivation of creative approaches to reflexivity. In the Global South, however, it is clear from our case that languages of experimentation must be accompanied by a robust consideration of the material barriers and

Table 1. Diverse potential roles for social science in responsible innovation (adapted from Bennett et al. 2017).

Social science roles	Examples include:
Descriptive	Understanding people and culture
Diagnostic	Identifying structural and infrastructural gaps
Disruptive	Re-routing technology trajectories; exploring alternative options in a meaningful way
Reflexive	Understanding assumptions, funding conditions, agendas
Generative	Generation of new issue publics, building capacity e.g. through infrastructures or through knowledge
Innovative	Culturally sensitive substantive engagement
Instrumental	Messaging and informing

political realities faced by social scientists. Social scientists from malaria endemic countries describe a number of factors that limit the application of social science insight in tropical public health as well as malaria control (Ngalame et al. 2004). Ngalame et al. (2004) point to the 'paucity of research centres' and 'limited funding for social science research,' with most job opportunities being limited to short-term career paths. Owusu, Kalipeni, and Kiiru (2014) similarly identify meagre funding and the continual under-valuing and under-resourcing of the social sciences as a major obstacle. As our workshop participants emphasised, it is notable that there is no funding for independent social science in gene drive in the Global South. The Bill and Melinda Gates Foundation, one of the most prominent organisations working in the global challenges space and the primary funder of gene drive research in Africa, currently offers no funding for independent social science in sub-Saharan Africa (Hartley, Kokotovich, and McCalman 2022). Further, such an influential and well-resourced actor makes it more challenging for the social sciences or activist movements to act as a critical counterbalance or offer an interrogation of gene drive or its governance. This gap means that there is little reflexivity surrounding the technological imaginaries that accompany the work of the Gates Foundation. Given that many African countries have not developed strong health governance systems, this can lead to health research priorities (and responses) being imported form foreign research and funding organisations which may 'distort [the] research focus on external priorities when local needs may be different' (Juma et al. 2021, 8).

Accompanying this pattern is a trend for academics to engage in consultancy work, which has been implicated in exacerbating a narrow policy orientation of African social research and in increasing a Global North dominance of the research agenda (Owusu, Kalipeni, and Kiiru 2014; Wight 2008). Consultancies are driven partly by inadequate social science salaries and stability, as well as by the opportunity they present to improve knowledge and skills. In some African countries like Uganda, funding for social science and humanities, including scholarships, research, recruitments, and salaries, has further been stifled by the open presidential policy of promoting natural sciences. The natural sciences are privileged in this way because they are believed to have the power to transform the economy, with natural scientists receiving higher pay than their social science colleagues (Parliament of the Republic of Uganda 2022).

While working towards equitable collaboration necessitates deep change at a structural level and in the complex fabrics of distributed governance which cannot be achieved by singular institutions, publics, or epistemic collectives alone (such as the RI community), there are, however, numerous levers that can support the cultivation of greater equitability. In some areas of global health, for example, manuscripts are discouraged where primary data collection has been collected in a LMIC without co-authorship (Urassa et al. 2021). There is a need for journals like JRI to actively seek articles from social scientists in the Global South rather than relying on Northern academics to articulate it. Career development networks have also been identified by social scientists in malaria endemic countries as key factors to support and strengthen social science in such countries (Ngalame et al. 2004). As we note in the funding declaration to this paper, four connected grants supported this work where two early career researchers, one in the UK and one in Uganda, developed from PDRA researchers to Co-Is, taking on more responsibility.

In line with RI's aspiration to direct research efforts towards broader questions of innovation governance and innovation systems in addition to specific technologies, we argue that making visible and attending to the infrastructures and processes that undermine and which can help to support the inclusion of the social sciences in its diverse forms is an important area of research for RI going forward. Piccolino and Franklin (2019), for example, have examined the impact of research risk assessment practices within UK and European universities. They argue that growing research risk assessment practices can mobilise contested and neo-colonial cartographies of 'danger zones,' which discourage long term field and ethnographic work, presenting unintended consequences for collaborative and African knowledge generation. This raises implications for, and can threaten to derail, aspirations not merely to recognise LMIC researchers as collaborative partners, but to enable 'equal opportunity for leadership rather than simply participation in cross-cultural social science' (Urassa et al. 2021, 669).

By adding to research efforts which make more explicit the various and multiple ways in which the social sciences can contribute to innovation trajectories both in the Global South and in the Global North, we have sought to offer a small contribution to the 'infrastructures' that can help to support diverse epistemic inclusion in robust ways. Making explicit the different forms of social science that can be mobilised within innovation projects can help to problematise instances within technology development practices where the social sciences are brought on board solely as engagement practitioners (ESA 2020), contributing to greater accountability and more robust practice. On a broader level, explicitly articulating and delineating the diverse value and contributions made by the social sciences (for example, in relation to the Ebola epidemic) can also help to change perceptions of the social sciences among researchers, funders, stakeholders and epistemic communities such as RI scholars. This can support moving beyond recurrent and reductive modes of epistemic organising. Indeed, too often the role of scientists is reduced to one of 'implementation specialists,' who can guide the operationalisation of top-down health interventions, 'context specialists' who can identify cultural idiosyncrasies that might get in the way of specific projects, or specialists in 'public opinion' who are able to pre-empt public concerns that might present hurdles to the rolling out of new initiatives. As we have highlighted in this paper, the social sciences can throw into relief complex processes and dynamics, help to redress asymmetries in knowledge and help capacitate processes which place publics and local actors more in the steering seat of innovation trajectories. Recognition of the value of the social sciences is, we suggest, an important part of ongoing efforts to develop strong health research governance systems (Juma et al. 2021), with potential to be formalised within national and institutional structures and systems.

Working towards equitable collaboration also requires recognising the value and contributions to be made to theory building by social science practices and endeavours in the Global South (Briggs and Weathers 2016). Macnaghten et al. (2014), for example, argue that innovation practices and processes in these spaces can serve as important sites of learning for RI practices in the Global North and certainly, in our case, established practices of local engagement with social referents in the Global South, as well as accumulated lessons surrounding how to engage communities amidst a backdrop deep mistrust, may provide important insights and cues for the development of innovation pathways in the Global North where institutional distrust and social polarisation are pressing policy

issues. We recognise, however, following Khan et al (2022), Haug (2021) and others, that terms such as the Global North and Global South are limiting and can reify problematic assumptions. We suggest that going forward it will be important to specify empirically, as we have sought to do in this paper, the social dynamics that shape realities in these spaces, so as to enable comparative analysis, theory building and mutual learning going forward. Indeed, as pointed out in a recent contribution by Harris et al. (2016, 5):

> You could make the argument that structurally, the Ghanian system is far closer to the UK system than the American system will ever be … .it is centrally administered, district-based health system, much like the NHS is. And so theoretically, ideas from Ghana would be more relevant than ideas from the US. But that's not how the learning works. And that's the cultural arrogance piece of the postcolonial legacy that I think interferes.'

Challenging assumptions and orientations in responsible innovation

Regularly reflecting on the assumptions and orientations imbued within the practices and theoretical leanings of RI, through empirical insights and data generated on the ground, is an important part of developing a more inclusive RI framework. This is imperative in supporting RI in its desire to provide a series of tools and inclinations that can help to steer innovation pathways and infrastructures, not simply in relation to high technology in the Global North, but in a diversity of settings and relationships. We have highlighted how, in the Global North, RI has advocated for critical forms of social science that gesture towards alternate social-technical futures (Macnaghten et al. 2014) and which are distanced from educational or communicational social science that can be co-opted into an instrumental or hand-maiden role. While RI has been quick to align communicational and educational forms of social science with processes of depoliticisation and a deficit model, these forms of social science have an important role to play in broader processes of capacity building and can help to redress asymmetries in knowledge. It would, therefore, be too quick and reductive a conclusion to simply attest that in the Global South, there is similarly an instrumental rendering of social science at play and that this presents an obstacle to the meaningful opening up of innovation trajectories. Reflecting on the assumptions imbued within the theoretical predilections of RI can help to open up a more inclusive reconfigured RI framework.

As well as the practical benefits stemming from social science engagement, social science can bring conceptual innovation too. Yet, Anugwom (2004 in Mouton 2010, 36) describes how 'the corpus of theoretical leanings and methodological orientations in African social sciences are mostly abstractions of Western models produced by scholars there,' with commentators pointing to the 'lack of indigenous African theories and conceptual models to address the dynamics and challenges of the region' (Mouton 2010, 36). This is problematic, given that not only are understandings of challenge issues that are removed from given challenges limited in their ability to inform robust and appropriate solutions, but also because the intractable or 'wicked' (Ludwig et al. 2022) nature of today's pressing challenges necessitates creative solutions and approaches that can only emerge from an attentiveness towards multiple ontologies and ways of thinking. As RI shifts to an attentiveness towards questions of governance and engages in renewed efforts to move the field forward in new ways (Fisher 2020), we have highlighted the diversity of roles envisaged for the input of the social sciences in technological

assemblages in the Global South, arguing that there is a need for RI to reflect on its own theoretical predilections as well as the infrastructures that support the inclusion of diverse scientific expertise (moving beyond a focus on the inclusion of publics and other stakeholders – see also Koch 2020).

The case of gene drive is an example of a high-biotechnology being developed to address a pressing global health challenge. As Schot and Steinmueller (2018) and many other innovation scholars point out, technological approaches to contemporary challenges can exhibit limits in their ability to effect change, particularly given their propensity to focus on the symptoms rather than the structural and systems dynamics that drive health and related challenges in the first place. Yet, we want to conclude by arguing that it is important not to place systems change and technology development in opposition to one another. The very process of technology development and appraisal can contribute to the cultivation of new capabilities, sociabilities and the connections necessary to empowering publics and rewiring social systems (Schot and Steinmueller 2018). In our data set, participants identified connections that could be mobilised to build momentum and capacity to amplify social science voices. These connections are relevant not just to gene drive but to innovations for health challenges more broadly. In this sense, the initiation of a technological project can contribute to the generation of networks and processes that reverberate and extend beyond the specific goals and aims of that particular project. Being alert to and tracing these reverberations is an important area of research for RI going forward. In sum, given the gravity of the pressing challenges that we are faced with today, attending to the nuances and complexities of practices and relationships as they unfold on the ground is an important part of building robust theory and impactful innovation solutions. We have demonstrated that it is not only important for RI to attend to forms of social science often associated with a deficit approach, but that these forms of social science and practices of social science in the Global South, can provide important insights and learning opportunities for responsible innovation processes going forward more broadly.

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Data access statement

This paper draws on secondary data analysis. Further information on the original data sets can be found in the connected published papers and workshop report referenced in the methods section.

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