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A retrospective analysis of responsible innovation for low-technology innovation in the Global South

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ABSTRACT

The role of low-technology innovation in addressing global challenges is undervalued. Responsible innovation (RI) has the potential to direct low-technology innovation toward global challenges in the Global South, yet this possibility remains largely unexplored. Through a retrospective analysis, this article explores how researchers grapple with dimensions of an RI framework in a research project and highlights key areas for researchers to consider when involved with low-technology innovation in a development context. The analysis demonstrates that RI can structure discussion and create space for anticipation, reflection and engagement with stakeholders. However, even when researchers are committed to the idea of RI, it is difficult to enact in practice. Although RI places significant emphasis on inclusive and meaningful engagement as imagined by co-development and inclusive models of innovation, the deficit model of public engagement presents a formidable barrier. Surprisingly, low-technology innovators are likely to face the same struggles as high technology innovators with regards to engagement that allows end-users to shape the technology which may ultimately benefit them.

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Global South; deficit model; high technology vs low technology; retrospective analysis

Abbreviations

GCRF	Global Challenges Research Fund
ICS	Improved cookstoves
RI	Responsible Innovation
UKRI	United Kingdom Research and Innovation

Introduction and theoretical underpinnings

Investment in science, research and innovation is an established approach for addressing global challenges. The role of *low-technology* research and innovation in addressing these challenges is often undervalued in the dominant assumption that *high-technology* innovation will drive economic development, particularly in European and North American

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countries (Hirsch-Kreinsen 2008). Even when low-technology or appropriate-technology alternatives are recommended, their advancement is impeded by a number of factors that favour high-technology solutions to global challenges (Vanloqueren and Baret 2009). To date, there has been limited attention to low-technology innovation in the development context. In the last five years, the concept of responsible innovation (RI) has emerged to direct research and innovation toward addressing social needs and global challenges (Owen et al. 2013) and in 2013, it was adopted by the UK's Engineering and Physical Sciences Research Council (EPSRC) as a framework for research funded by this organisation. RI proposes a framework for inclusive research that allows communities and stakeholders the opportunity to shape a technology that might impact them in order to increase the public value of such a technology. To date, RI has mainly been applied to high-technology innovation in the Global North. There is a significant gap in the literature relating to the application of RI in low-technology, Global South contexts (Macnaghten et al. 2014), or outside Western liberal democratic contexts (Wong 2016). We explore this gap through a retrospective analysis of an EPSRC-funded engineering project exploring why there had been limited uptake of improved low-technology cookstoves in Southern Africa. The analysis is retrospective as the project funding application was made prior to the RI framework being adopted by the EPSRC.

Efforts to promote development in low-income countries in the Global South have long been associated with externally imposed, top-down and locally insensitive approaches (Escobar 1995). From the late 1940s in particular, the notion that Global North countries represented the model for the rest of the world to follow was accompanied by sustained efforts to transfer capital intensive technology from 'developed' to 'developing' countries (Pretty and Shah 1999). The possibility that the success of such approaches would depend on a broader set of social and cultural factors was largely unforeseen (Escobar 1996). However, the detrimental socio-economic and environmental impacts of this technology transfer approach started to gain attention along with a wider set of socio-environmental problems linked to 'top down' forms of development more generally (Goldsmith et al. 1972; Meadows 1972; Shiva 1988). In many cases, issues linked to a lack of a developed supply chain undermined the sustainability of technology transfer initiatives (Agunwamba 1998; Urmee, Harries, and Schlapfer 2009).

The wastage and socio-environmental damage associated with technological solutions to development highlighted the need to address critiques of 'top down' and locally insensitive approaches through greater consideration of the wider socio-economic, cultural and ecological contexts into which they would be inserted (Leach and Scoones 2006). At the same time, increased attention to indigenous knowledge and 'appropriate' or 'intermediate' technologies (Schumacher 1973) helped to encourage a shift towards more bottom-up development initiatives. These initiatives tended to focus on the need for development research and planning to be sensitive to different socio-economic, cultural and environmental settings (Escobar 1995; Neefjes 2000) and embodied the replacement of wasteful or irresponsible technological solutions with more responsible innovations that could be created and maintained without external assistance. Nevertheless, the initiatives and frameworks themselves (as is the case with RI) and often the funding supporting or promoting them, usually continue to originate in the Global North.

Despite these Global North origins, RI is under pressure to be relevant to the Global South and research into its transferability is emerging (for example, De Hoop, Pols, and Romijn 2016). Macnaghten et al. (2014, 4) suggest that if RI is to have value in the Global South it must acknowledge 'local contexts, cultures and practices' (emphasis in

original), particularly the political economy and power dynamics in different geographic regions. This need for sensitivity to local context is well established in the development literature that addresses science and technological innovation and has the potential to limit the wholesale transferability of RI to development contexts (De Hoop, Pols, and Romijn 2016; Leach and Scoones 2006). However, emerging empirical cases of RI in the Global South suggest that some elements of RI may be transferable. For example, Biddle (2017) explores whether a project to bring genetically modified crops to sub-Saharan Africa can be considered a case of RI. He suggests that a technology might be considered a responsible innovation if it addresses a societal challenge that is locally defined, the technological research is conducted in local contexts, and the technology is accessible to those who need it most.

More recently, the concept of 'inclusive innovation' for development has gained prominence in both academic and policy contexts; informing practical outcomes in the process (Chataway, Hanlin, and Kaplinsky 2014; Fressoli et al. 2014; Heeks, Foster, and Nugroho 2014; Johnson and Andersen 2012; OECD 2012; Pansera and Owen 2018). Pansera and Owen's (2018) critical discussion of the ways in which inclusive innovation is framed, emphasises the highly political and contested nature of this term. They highlight the multiple, contrasting, and sometimes competing, perspectives which now inhabit the political economy of grassroots innovation. In particular, Pansera and Owen argue that inclusive innovation needs to be more comprehensively explored through empirical examples which take into account the discursive position of the various actors deploying this term, so that market, social, environmental framings are made explicit. However, De Hoop, Pols, and Romijn's (2016) empirical work on RI through a case study involving a biofuels project in India suggests that power imbalances significantly limit engagement and may eliminate engagement opportunities altogether. Inclusive innovation may offer RI guidance for its applicability in Global South contexts through its emphasis on engagement and inclusivity.

Cozzens (2012) highlights how forces of inclusion and exclusion operate at the global level, citing the work of Manuel Castells, who argued that the most detrimental impact of the global economy is not to be exploited, but rather to be irrelevant. In particular, those people living in rural, subsistence habitats, or informal settlements in urban contexts are at risk of being excluded and made irrelevant because of their lack of access to information networks and exclusion from official data collection tools such as demographic and health survey questionnaires, which typically do not include households in urban slums or informal settlements (WHO and UNICEF 2015). The issue of inclusive and 'relevant' innovation also links to the impact of resource scarcity on people living at the 'bottom of the pyramid'. Drawing on an ethnographic study in Bangladesh, Pansera and Owen (2015) emphasise the importance of considering how narratives of development emerge through a process of hybridisation. In other words, innovation narratives in any given local context need to be understood as emerging through a 'combination of factors incorporating, resource scarcity, institutional weakness/voids, environmental constraints and urgent social needs' (Pansera and Owen 2015).

Given the EPSRC's adoption of an RI framework, there is a strong argument for it to embrace these concepts of relevance and inclusiveness if it is to achieve its goal to direct research and innovation towards addressing social needs and global challenges. Despite the rapid diffusion of the performative idea of 'grand challenges' (Ulnicane

2016) to mobilise science and technology to increase the livelihoods of people in the Global South, RI has been preoccupied with high-technology cases predominantly for the benefit of Northern populations, including geoengineering, robotics, nanotechnology, information and communications technology and synthetic biology (Eden, Jirotka, and Stahl 2013; Stilgoe, Owen, and Macnaghten 2013; Robinson 2006; Stahl et al. 2014). Calls have mounted for a broader conceptualisation of innovation (Blok and Lemmens 2015; de Campos et al. 2017; Chaturvedi, Srinivas, and Kumar 2016; Parkhill et al. 2013; Wickson and Forsberg 2015). Yet, relatively few studies have examined RI in the context of low-technology alternatives to addressing global challenges outside Europe and North America. For those seeking to apply RI in these contexts, there is little guidance on the practical aspects of doing so (de Campos et al. 2017; Chaturvedi et al. 2016; Voeten et al. 2014).

In order to explore the potential of an RI framework for low-technology innovation in the Global South, we conduct a retrospective analysis of an EPSRC-funded project seeking to identify barriers to the uptake of improved low-technology, or appropriate-technology, cookstoves in Southern Africa. We examine what RI might look like in practice, explore how researchers grapple with dimensions of the RI framework in the design and conduct of research, and draw practical lessons for projects involved with low-technology research and innovation in a developing context. We find that even when researchers are committed to the principles of RI and well aware of the limitations of the deficit model and transfer of technology approaches, it can be difficult to enact. Despite these challenges, our results suggest that an RI framework can structure discussion and create space for anticipation, reflection and engagement with stakeholders. As such, it offers a practical agenda that could help project teams identify important socio-technical elements of innovation early on in the project planning stage and facilitate engagement with stakeholders and other publics to steer research toward locally-defined social needs. However, although RI places significant emphasis on inclusive and meaningful engagement as imagined by co-development and inclusive innovation models of innovation, the deficit model of public engagement presents a formidable barrier. Surprisingly, it would seem that low-technology innovators are likely to face the same struggles as high technology innovators with regards to engagement that allows end-users to shape the technology which may ultimately benefit them.

Research design

We take the *Understanding the barriers to the introduction and uptake of clean/improved cookstoves in Southern Africa* project ('Barriers project') as a case study. Case study research allows us to understand a complex issue or situation and also build on previous knowledge (Stake 1995; Yin 2009). This methodological approach enables us 'to answer "how" and "why" type questions, while taking into consideration how a phenomenon is influenced by the context within which it is situated' (Baxter and Jack 2008, 556). Importantly, by adopting this method, we were able to capture and analyse detailed contextualised information from the Barriers project, which we could then retrospectively evaluate through the application of an RI framework to this work.

The interdisciplinary collaboration foundation to this article began at a University of Nottingham workshop on RI where the members of the Barriers team expressed their

interest in the RI framework and the values underlining it. They felt that adopting the RI framework at the outset of the project would have helped them in operationalising the project goals. Likewise, the RI researchers expressed interest in exploring the elasticity of RI in a low-technology innovation in the Global South. Social scientists (Hartley and McLeod) set up an initial meeting with UK-based members of the Barriers project team (Clifford, Jewitt and Ray) where we decided on the direction and analytical framing of the article. Information was then collected through a series of interrogative meetings with individual members of the Barriers project and one focus group with the UK investigators of the project team. The first meeting explored the Barriers project, relationships between the UK and overseas members of the research team and the successes and challenges of the project. The social scientists carried out a documentary analysis of project outputs, including papers, blogs, reports and websites. Together, we decided to apply an RI lens retroactively, and with the benefit of hindsight, to evaluate RI's potential application to low-technology innovation projects as they design and conduct research that supports the development of low-technology innovations in the Global South in response to the global challenge of clean energy. There was agreement that a retrospective analysis could be a useful way to learn lessons quickly so that they could be applied to future projects.

Applying RI as an analytical framework for the Barriers project

Our case study analysis of the Barriers project was based around the four dimensions of the EPSRC's 'Framework for Responsible Innovation' to understand how RI might be operationalised in future practice. Table 1 shows the four dimensions of RI that formed the basis of our analytical framework: anticipate, reflect, engage and act. The EPSRC adopted the RI framework in 2013 and since then has developed an explicit policy that states its commitment to develop and promote RI as well as expecting the researchers and research organisations it funds to implement the policy, particularly in strategic thinking, funding plans and proposal assessment (EPSRC 2018). It defines the concept as such:

> Responsible Innovation is a process that seeks to promote creativity and opportunities for science and innovation that are socially desirable and undertaken in the public interest.

Table 1. The EPSRC's AREA framework for RI (EPSRC 2018).

	Researcher activity
[A]nticipate	*Describe and analyse* intended and unintended impacts (including economic, social, environmental impacts). Think about and imagine possible trajectories: What else might the research lead to?
[R]eflect	*Reflect* on the purposes, motivations and potential impacts (what is known) as well as uncertainties, risks, assumption, areas of ignorance, dilemmas (what is not known). Question existing framings and understand others' framings. Reflection requires openness and leadership and must be institutionally embedded.
[E]ngage	*Open up* 'Anticipate' and Reflect' to a wide range of publics, stakeholders and institutions and debate them in an inclusive way to allow for the re-framing of issues. Engagement needs to be institutionally embedded. Engagement should be held early enough to be constructive but late enough to be meaningful and should be driven by normative (the right thing to do) and substantive (improves nature and trajectory of innovation) motivations.
[A]ct	*Take action* to allow these processes to influence the direction, trajectory and pace of the research and innovation process, responding to a wide range of publics, stakeholders, social needs and societal grand challenges.

> Responsible Innovation acknowledges, that innovation can raise questions and dilemmas, is often ambiguous in terms of purposes and motivations and unpredictable in terms of impacts, beneficial or otherwise. Responsible Innovation creates spaces and processes to explore these aspects of innovation in an open, inclusive and timely way. This is a collective responsibility, where funders, researchers, stakeholders and the public all have an important role to play. It includes, but goes beyond, considerations of risk and regulation, important though these are.[1]

Cookstoves and the Barriers project

It is estimated that 3 billion people worldwide rely on solid biomass fuels (fuelwood, charcoal, animal dung, grass, shrubs, agricultural residue) to meet their basic cooking and heating needs (WHO 2016). Many of these people cook using traditional methods (such as open fires), often in poorly ventilated spaces (Akintan, Jewitt, and Clifford 2018). There are many negative impacts associated with the use of solid biomass including chronic and acute health problems (e.g. respiratory disease), environmental issues (e.g. deforestation), carbon monoxide emissions (traditional cooking methods are estimated to contribute around a third of global carbon monoxide emissions), and gender disparity (women suffer the greatest share of health, time-loss and physical impacts of solid fuel use) (Lim et al. 2012; WHO 2016).

Innovation within the cookstove sector has changed in emphasis over time from what was seen as a straightforward technical challenge of increasing fuel efficiency during the 1970s and 1980s, to more user-focused interventions in the 1990s (Barnes et al. 1994; Germann 1995; Sesan 2014; Westhoff and Germann 1995). These user-focused inventions paid attention to socio-cultural and economic factors influencing cookstove preferences. By the mid-1990s, the implications of biomass burning for climate change and respiratory health came to the fore and attention shifted towards clean, rather than efficient, stoves. At the same time, increasing emphasis on market-based approaches within the development sector brought a shift away from programmes promoting subsidised stoves. This often resulted in commercially produced stoves that offered greater technological efficiency and reduced emissions but which were often unaffordable for lower socio-economic groups and inappropriately designed for end-users (Jewitt and Rahman 2017 ; Sesan 2014; Simon 2010).

The Barriers project was a £685 k, three-year research project (2013–2017) funded by EPSRC, Department for International Development (DfID) and Disasters Emergency Committee. The project aimed not to introduce new cookstove technologies, but rather to understand the obstacles that have prevented the large-scale uptake of improved cookstoves (ICS) in Southern Africa using the broad hypothesis that there has been greater market penetration and success in East Africa. A key emphasis was on developing better understandings of end-user cooking practices/priorities and the communication of these (along with the development of tools to achieve this) to key ICS stakeholders including stove producers and energy policy-makers.

The project was funded as part of a suite of thirteen projects under the Research Council UK, DfID and Disasters Emergency Committee research programme *Energy and International Development: Understanding Sustainable Energy Solutions in Developing Countries*. Since the initial call in 2012, the Barriers project has been incorporated into the

'Low Carbon Energy for Development Network, Energy and International Development: Understanding Sustainable Energy Solutions in Developing Countries Programme', which intends to increase clean energy access, resilience and wealth creation in developing countries (particularly for the urban and rural poor), through high quality research that improves the understanding and evidence-base of opportunities and challenges associated with clean energy for development.

Academic researchers developed project proposals during a three-day sandpit event held in Nairobi, Kenya, which included representatives from the third sector. During the sandpit, participants discussed the challenges relating to clean energy access and scoped out themes where collaborative academic research could make a genuinely positive impact on energy poverty in low and middle income country contexts. Partnerships were formed at the sandpit, with collaborative research projects pitched to a judging panel at the end of the event in a poster presentation session. Successful project ideas were invited to submit full proposals using the standard EPSRC application forms.

The Barriers project, led by the University of Nottingham, UK, comprised of academic partners: Centre for Petroleum, Energy Economics and Law (Nigeria); Lilongwe University of Agriculture and Natural Resources (Malawi); and the Energy Research Centre, University of Cape Town (South Africa). Non-academic partners consisted of Ashden and the Centre of Energy, Environment and Engineering Zambia Limited (UK and Zambian non-governmental organisations) and Practical Action Consulting (international development charity). Most of these organisations had not previously worked together and had limited information about the capacity of the other partners to carry out the tasks allocated in the proposal but all were familiar with working in low and middle income countries.

The Barriers project set out to analyse the ICS sector and to better understand the barriers to the adoption of ICS (designed to burn biomass fuels more cleanly and efficiently than traditional cooking methods), with a particular focus on South-South learning and knowledge transfer. A variety of approaches have been used to promote ICS adoption including community-focused participatory schemes, government subsidisation programmes and market-based commercial activities (Sesan et al. 2018). One notable example of a successful ICS initiative is the Kenyan Ceramic Jiko, developed in the 1980s, and now used by 87% of urban homes (Ashden 2015). This cookstove is presently considered the baseline charcoal stove in Sub Saharan Africa (Roth, Moore-Delate, and Messinger 2016). Despite this success, adoption rates and sustained use of ICS remain low globally and the reasons as to why this is the case are only partially understood.

The Barriers project employed a qualitative methodological approach to explore the non-technical dimensions of improved stove dissemination, in contrast to the quantitative, techno-centric approach adopted by the majority of cookstove initiatives. The project was inductive and broad in scope to allow research findings to shape the development of initiatives seeking to promote ICS adoption

The cookstove sector has changed considerably over the last forty years, with an increasing emphasis on behaviour change – notably communication and marketing – approaches given the previous failures by governments and charitable organisations to facilitate large-scale ICS uptake (Sesan et al. 2018). The launch of the influential 'Global Alliance for Clean Cookstoves' in 2010, with a headline-grabbing target of introducing 100 million clean stoves into houses across developing countries by 2020, has elevated cooking to the global political agenda. This forms part of the broader energy agenda

where initiatives such as 'Sustainable Energy For All' and inclusion of an indicator on access to clean fuels and technology in Sustainable Development Goal 7 have put household energy access and 'clean' cooking on the global stage.

The hypothesis that there is greater uptake of ICS in East Africa in comparison to uptake in Southern Africa was found to be only partially true. Whilst there has been greater success of adoption in Kenya, the ICS sector has been active for over 30 years and where access to and uptake of ICS has been relatively good in urban areas, there has been limited uptake in rural areas. The situation in both Tanzania and Uganda is less prominent (despite a plethora of interventions) and when the ICS sector in East Africa is referred to as a success, Kenya is the most common example used. The ICS sector in Southern Africa can be considered less developed than in East Africa but there are many similarities. For example, the ICS sector in Malawi has rapidly grown since 2010 and despite low rates of adoption, the attention given to the sector by Government, NGOs, academics, and donor organisations is similar to that in many East African countries. At the same time, the limited uptake of ICS in rural areas in comparison to urban areas is demonstrated in both regions.

The barriers to the adoption and sustained use of ICS identified during the research phase were similar to the barriers presented in much of the ICS literature (Ray, Clifford, and Jewitt 2014) although significant context-specific variations were often present within the different types of barrier identified. These included:

- Financial – Initial cost of stove, cost of fuel, microfinance access for both ICS businesses and end-users.
- Technical – Designing a stove that meets end-user requirements (height, weight, portability etc.), improved efficiency, reduction of smoke emissions.
- Gender – Women as entrepreneurs, understanding household gender dynamics, involvement of both men and women in purchase decision.
- Market – Distribution, marketing and sales capacity, business support, sufficient infrastructure.
- Political – Lack of government support for stove programmes, financial commitment, VAT/ import duties, forest management, regulation, standardisation and quality assurance of ICS.
- Socio-cultural – Education, awareness, understanding household dynamics, cultural practices, preferences for traditional cooking methods, household aspirations.

In addition, the Barriers project highlighted the importance of gaining an in-depth understanding of end-user preferences in different areas in order to analyse the rationale for ICS adoption (or not in some cases). For example, it is clear that the use of multiple fuels and technologies is the norm in many households and 'stove stacking' (Masera, Saatkamp, and Kammen 2000) is something that needs to be incorporated as part of ICS initiatives rather than ignored with a sole focus on a particular technology. This issue came out repeatedly in interviews as householders explained the advantages of having a range of stoves to cook with at different times and in response to factors such as changing fuel price or availability, weather conditions, the type of food being cooked or the number of people being catered for. In Malawi, one householder stated '[I use] Kenyan Jiko. [It] uses charcoal and less fuel. Chitetezo is fast but sometimes wood is not available'.

Similarly, in Kenya a householder stated 'LPG – Cooks fast, Kenyan Jiko- food tastes better', highlighting some of the key factors underlying fuel and stove choices.

At the same time, existing household cooking practices, priorities, aspirations and underlying cultural norms are integral to the adoption of ICS. For example, in both Malawi and South Africa, examples were given that women should not cook when menstruating and in Kenya half of the interviewees explained that the kitchen and cooking is 'women's and girl's work exclusively'. In Mozambique, many interviewees explained the need to engage in discussion about ICS with one explaining that 'more debate and talks [are needed] to understand the difficulties people see or felt'. Ultimately though, there is sometimes significant resistance to change (especially in rural areas) where established cooking practices are valued for a range of pragmatic and cultural reasons that education and ICS promotion initiatives may have little influence on (Akintan, Jewitt, and Clifford 2018). For example, an energy consultant in Kenya stated 'I used to send my Grandmother stoves all the time but I have given up. She doesn't believe in this type of modern technology'.

The severity of these barriers varies considerably in different contexts (country to country, from region to region, from rural to urban settings and even from kitchen to kitchen). Despite lip-service being paid to end-user preferences, the deficit model often applies, with stove manufacturers, distributers and stove promoters seeing technological innovation and education/raising awareness as high priorities, whereas at the household level, acquiring an ICS is often well down the list of household priorities. This project found that a one size fits all approach does not work when trying to facilitate adoption and sustained use of ICS. Instead, there need to be greater efforts understanding end-user preferences.

The Barriers project through EPSRC's AREA framework

In this section, we take each of the four dimensions of the AREA RI framework and examine the way in which the project team operationalised them. For each dimension, we have drawn on specific examples illustrating the way in which it was operationalised and discuss the specific opportunities and challenges. We iterate that there was no expectation for the project team to operationalise these, and this analysis is retrospective in nature.

Anticipate

Anticipation, as defined by the AREA framework, did not occur in practice in a formal way. As in any large scale, multi-partner project, Barriers encountered problems which could have been addressed earlier on had formal mechanisms been established for anticipation. These problems were more about the failure to anticipate the different perspectives and methodological expertise of team members which resulted in tensions about how the research was to be conducted and where the focus of the field research would lie.

In an attempt to counter the techno-centric approach of traditional engineering projects with a proposed technology being central to the case for support and limited attention to user needs, the Nottingham team viewed the project as broader in scope and more focused on exploring end-user preferences (Ray, Clifford, and Jewitt 2014). In seeking

to identify place- and culture-specific barriers, they sought to produce a roadmap for how technological innovation could have greater long-term impact and identify where lessons could be learned from end-users. This included where ICS fitted within broader household priorities and how barriers to ICS uptake (if indeed this was desired) could be overcome.

With that in mind, it was decided that this project would collect data in seven countries (Kenya, Uganda, Tanzania, Malawi, Zambia, Mozambique, South Africa) based on the geographical locations of project partners and their experiences working in each country. At the same time, although cookstove users were the primary focus of investigation for this project, it was deemed important to also gain insights from other points along the ICS value chain (policy-makers, NGOs, finance providers, producers, enabling environment, manufacturers/producers, distributers, retailers and consumers) to provide a holistic perspective of the different barriers encountered. With the benefit of hindsight, the project was over-ambitious given the resources. Instead, the team should have concentrated on fewer locations (countries) and selected a single unit of investigation which could have led to more specificity in the overall findings/outcomes. However, the team felt that the problem with this approach was that with a consortia of partners that had never worked with each other before, it was difficult to anticipate their reaction if change to the scope of the proposal had been suggested so soon after the project had been funded.

Reflect

The initial project meeting held in October 2013 focused on logistics, formalities and re-familiarising project members with the proposal rather than fully engaging in the complexities (and indeed anticipated challenges) of the project. As such, all partners agreed that the shape of the proposal was acceptable to take forward. It was not until the first annual review meeting in October 2014, however, that it became clear that project partners had very different overall visions for the direction that the research should take and the overall scope of the project. The deliberately broad project scope resulted in some (mostly healthy) debate around research methodologies, concepts and terminologies. For example, several different views were expressed as to what constituted an 'improved cookstove' with some partners wishing to focus exclusively on the most advanced technologies using electricity or LPG as fuel, whereas others saw improved biomass (wood/charcoal) stoves as worthy of investigation. The debate surrounding the terminology of an improved cookstove is something that is still unclear in the literature. In light of this, the Barriers team produced a paper that further unpacks this ambiguous terminology, raising the question: 'improved' for whom?

The different backgrounds and capacities of the project partners coloured the discussion and highlighted deficiencies in the understanding of qualitative methodologies amongst some key partners who were initially tasked with work packages which required these core skills. It resulted in debates around sample size, with some partners less experienced in participatory and interview-based methodologies favouring structured questionnaires that produced large quantitative data sets that they felt would be more convincing to policy-makers. This contrasted with the Nottingham team's preference for a smaller sample to allow more in-depth data on end-user perspectives, priorities and constraints to be collected with a view to informing more inclusive forms of innovation and technology development. They were particularly interested in understanding how cooking- and

fuel-related priorities and preferences varied with factors like location, socio-economic status, ethnicity, gender and age and finding ways to communicate these understandings to stove producers and policy-makers. South-South knowledge transfers between stove producers working in different African countries were viewed as particularly important for countering potential critiques linked to the project's funding originating from the Global North.

At a project meeting held in October 2015, there were many discussions regarding data analysis given the limited experience of some partners in implementing qualitative methods but the overall feeling was to ensure that the project finished well. In hindsight, earlier and more detailed discussions between project partners regarding the targets of the research (end-users, stove producers or policy-makers) and the most appropriate and effective ways of engaging and co-developing knowledge with these stakeholders should have been addressed from the outset.

Engage

There were different aspects of engagement throughout the project. First, as highlighted above, there was engagement between the different members of the project team. There were three annual project meetings in October (2013–2015) where most[2] team members were present for a 2–3 d meeting. In addition, there was direct engagement between project partners and the Nottingham team over the course of the three years with occasional visits to in-country partners to consolidate a rapport, address any challenges and directly be involved in the data collection process. This consisted of field visits between project partners based in Malawi and Kenya,[3] as well as with partners in Zambia and South Africa.[4] Aside from face-to face interactions, there was also online activity including regular Skype calls and emails providing details on a variety of issues such as data collection updates, action points from meetings, notification of deliverable deadlines. Key drawbacks included connectivity issues with Skype calls plus a high number of personnel changes, which sometimes slowed progress as new team members sought alternative research directions or approaches. In an effort to avoid North–South transfers of knowledge and research approaches (including those set out in the RI framework), the Nottingham team sought to promote open dialogue between project partners and keep the project broad enough in scope to accommodate partner-specific variations in expertise and country-specific variations in cooking technologies/priorities.

Another key aspect of engagement within the Barriers project, involved partners and stakeholders directly. As mentioned, project partners were from a variety of sectors, selected for their knowledge, experience and expertise in one or more of the selected countries. Each partner and their associates (enumerators, research assistants, colleagues etc.) can be considered local experts as they understood the local context, as well as socio-cultural, geo-political and environmental factors. More importantly, these partners facilitated access to research participants and made data collection possible. It is through this engagement that the team was able to identify households in urban, rural and peri-urban areas, relevant government ministries and financial institutions to interview, and a range of stakeholders along the market chain comprising of producers, distributors and retailers. These actors were mainly engaged on a face-to face basis to collect data but on occasion (as a result of Nottingham field visits), there was continued dialogue through Skype or email.[5]

As this project primarily targeted cookstove users and sought to understand their priorities rather than promote a particular technology, there was a lot of emphasis on going beyond traditional techno-centric approaches to engage with end-users and producers in order to understand the wider socio-economic, cultural and environmental contexts into which the innovations would be placed or produced. The scope of the end-user engagement envisaged by the Nottingham team became difficult to realise in practice partly as a result of the capacity of some in-country partners to collect qualitative data but also because there were simply not enough resources. In particular, the Nottingham team wanted to collect additional qualitative data beyond the household questionnaire they employed (such as focus group discussions, narratives or other participatory exercises that would allow more in-depth explorations of user priorities) but because households were not the only line of investigation and data from policy makers, value chain and financial actors needed to be collected, there was a limit to how much could be achieved.

With this in mind, the Nottingham team sought to create opportunities to engage end-users and other actors (such as other academics, policy makers and practitioners) and co-produce knowledge and understandings. In order to trial novel approaches for engaging different stakeholders and understanding how cookstove use, priorities and cooking methods varied regionally, the team organised two 'bake-off' events in Nottingham with participants from Nottingham Refugee Forum; a community group with members from a range of African countries. As the name suggests, the idea of the 'bake-off' was based on a popular TV show (*The Great British Bake-Off*) in the UK.

Drawing on participatory approaches designed in the Global South to enable knowledge co-production by agricultural scientists and farmers (Chambers 1981, 1985), the bake-off involved a range of activities designed to enable these participants to communicate their cooking preferences and views on a variety of African cookstoves. Together with ICS stakeholders and researchers from different academic disciplines, and following lively discussions, they identified and ranked key criteria that they associated with improved cookstoves.[6] The volunteers all had previous experience of cooking on biomass stoves from their country of origin and were enthusiastic to cook typical dishes from these areas. The Nottingham team found that the process of engaging end-users on campus prior to working with resource-poor users in the southern African study sites was valuable for co-developing understandings of culturally-rooted cooking preferences and approaches and building these into the research design.

In collaboration with in-country partners from Malawi and Zambia, some of the key participatory approaches used in the Nottingham bake-off were adapted for use in two larger events which took place in 2016. As the idea of a 'bake-off' would not easily translate outside the UK, the name was changed to the 'Great African Cook-Off' to represent the primary role of stoves.[7] Both of these events sought to further explore the idea that some ICS fail to meet end-user requirements and to provide opportunities end-users to provide feedback on existing ICS technologies to key stakeholders (including ICS producers and retailers) in the market place. The events provided the team and a range of participating stakeholders with important context-specific insights into end-user stove priorities, how users interact with the stoves and how that could impact on adoption and sustained use.

In Malawi, the Barriers project team presented results from the project at the 2016 'Clean Cooking Conference,' which brought together a range of international and national

ICS stakeholders including stove producers and government officials and was able to host the Malawi Cook-Off at the conference open day as part of other stove related events. Drawing on participatory approaches that had proved successful at the Nottingham event, the team invited volunteers (based on the contacts they had made over the duration of the project) who cooked a variety of local dishes to be tasted. The guest of honour for the event was the Malawian Minister of Energy who spent time observing the cooking process and engaging in dialogue with the participants regarding the criteria they associated with an improved cookstove. This produced some interesting discussions as the cooks tended to identify features such as heat control, fast cooking and ability to cook locally favoured foods well while stove producers tended to prioritise smoke reduction and fuel efficiency. In Zambia, while the methodological approach was similar to that used in Malawi, the team partnered with colleagues in Lusaka as well as a South African Organisation (called Greenpop who they had previously met during the October 2014 project meeting) who host their 'Festival of Action' event in Livingstone every year. Rather than a focus on stoves or technology, this organisation focuses on environmental education around tree conservation/restoration and has promoted the use of ICS to reduce deforestation in Zambia. This event not only brought together local volunteers to cook on a range of ICS and provide feedback on preferences, but also actively sought to invite participants from local government, local media, schools and universities, local organisations and ICS producers and retailers (some of which made the journey from the capital Lusaka).[8] Greenpop organised the cooking activities in a lively manner, encouraging festival participants to engage with the cooks, taste the food and get involved in producing a matrix ranking for the different stoves.

Act

To act, the fourth dimension of the AREA RI Framework, most obviously emerged in dialogue with end-users and the impacts of the different cook-off events. In terms of meeting its objectives of improving and communicating understandings of end-user stove preferences, the project was successful in creating opportunities for knowledge sharing between different ICS stakeholders. The original Nottingham bake-off event successfully brought together a variety of stakeholders from different disciplines, encouraging significant knowledge sharing and co-production between stakeholders and cooks regarding different stove and fuel attributes, health and safety concerns and cooking-related cultural norms. A representative from DfID noted:

> 'The event was a positive and interactive platform to demonstrate the cookstove technology being used [as part of] the Barriers project. There was an atmosphere of collective learning and I engaged in interesting conversations with other participants and cookstove users. These conversations offered necessary insight into the usability of the technology and added a valuable, real dimension to the research being carried out.'

At the Zambia and Malawi events, the opportunity to observe different stoves in action and taste the food cooked on them resulted in stove producers and sellers re-thinking key stove characteristics including heat regulation, durability, re-fuelling methods and ability to accept large cooking pots that they had not previously considered important. The participation of key stakeholders including the Malawian Minister of Energy,

Greenpop, stove producers and local government officers also offered opportunities to disseminate end-user perspectives more widely to people in positions to act on them.

With regard to acts related to the broader management of the project, a key event was the October 2014 annual project meeting where it was clear that the team had not anticipated the differing views among partners regarding the stakeholder groups that the project would focus on and the methodologies to be used in the research. Conscious efforts were made from then on to address potential challenges and find a mutual consensus going forward. This, however, resulted in the Nottingham team leading the research, setting various deliverables and timeframes as well as being the first to engage in dialogue which rather undermined their desire for the project be co-developed with in-country partners. Progress was ultimately slower and may well have been different if these issues had been identified at the initial meeting in October 2013 and addressed during the first year of the project.

Discussion and retrospective analysis

Although we were unable to apply RI in retrospect, conducting a retrospective analysis of the project through an RI lens revealed several themes which we characterise here. This retrospective analysis required the Nottingham Barriers team to work through the RI framework and reflect on what could have been done better. This analysis draws some clear lessons for future project planning by the Nottingham Barriers team and provides important lessons for low-technology research and innovation in a developing context more generally. First of all, RI is difficult to operationalise, even when researchers are committed to this idea. The Nottingham Barriers team was committed to the values underlining RI and so were well placed to action RI dimensions, yet they faced a number of challenges that tested the project. The team found it hard to operationalise RI even with hindsight. The retrospective analysis revealed the lack of knowledge about a practical framework through which to enact RI. Such a framework could have supported the Nottingham Barriers team in the field and in their own discussions internally. In particular, the value conflicts which played out in the project could have been identified and addressed early on. As it was, some of these conflicts surfaced at inopportune times in the project, were not discussed openly during the course of the project, and never satisfactorily resolved. Engaging with the RI framework in the project planning stage could have offered a practical tool to structure discussions and create space for reflection and engagement with stakeholders.

Anticipation of the different priorities for stakeholder engagement and methodological preferences of the project team did not occur and was assumed to be done by project partners. The retrospective analysis showed that an anticipation exercise early on might have helped make the project run more smoothly. While the project team had anticipated that ICS adoption would be influenced by significant regional and context-specific differences in socio-economic, cultural and environmental factors, there was less agreement on which methodological approaches could be used to explore and identify these. It also became apparent that some project partners associated significantly different meanings with the phrase ‘improved cookstoves’ (Ray, Clifford, and Jewitt 2014). For one UK-based project partner this meant more expensive, high end cookstoves that use electricity/gas. RI might have helped open up this discussion in the project development phase and

could have helped structure the research questions and sharpen the focus on particular types of ICS. The RI dimension of 'anticipation' could be used to highlight embedded assumptions held by participants as well as capacity and expertise in different methodological approaches and connections with key stakeholders. This approach would have helped identify differing team member understandings of the project's goals and the nature of the methodological approaches needed to achieve these goals, as well as challenge problematic assumptions made by the Nottingham team about local partner expertise and their networks on the ground. In particular, an RI approach would have highlighted the unfamiliarity of some local partners with using qualitative methods for data collection and the subsequent tensions that emerged in the project. Therefore, the RI framework could have provided a structure for thinking about how to meet global challenges and build capacity in local contexts by avoiding the traditional model of UK-based development 'experts' flying in to do the work and then flying out (Chambers 1981).

Very little work has been conducted on RI in a development setting. At the same time, the EU and UK challenge-led research agendas are promoting co-development and co-creation models of research. The UK's Global Challenges Research Fund is a good example (GOV UK 2017). However, the narrative of co-development in challenge-led research agendas is rhetorical and does not offer practical frameworks for thinking about what co-development means on the ground for projects working with partners in development settings. Co-development demands a re-conceptualisation of science and society's relationship, breaking down traditional barriers between types of knowledge and developing technology in a socially robust and culturally sensitive manner (Nowotny et al. 2001). RI is not discussed in these co-development narratives in a development context. However, there may be even more need for RI frameworks in innovation research in Global South countries given the challenges of working in a development setting (Chambers 2008).

Responding to Pansera and Owen's (2018) call for critical exploration of the politics of inclusion, we might hypothesise that researchers are closer to the end-user in low-technology innovation (more so than in high-technology innovation) and therefore it should be easier for end-users to shape the technology. However, our analysis challenges this hypothesis. Instead, the analysis reveals that the 'deficit model' of public engagement (Wynne 2006) with high technologies is just as pervasive in low-technology development in the Global South. The idea that public resistance to science and technology is necessarily based on ignorance and fear, rather than allowing that people may have legitimate values-based concerns, is only changing slowly (Felt and Wynne 2007; Kerr, Cunningham-Burley, and Tutton 2007; Wynne 2006). Cookstove development in Africa is still expert driven and end-users have little ability or opportunity to shape the technology that is designed for them. RI challenges this deficit model and provides a framework for reflecting on the assumptions held by researchers. However, as Pansera and Owen (2018) found in their research on inclusive innovation in India, RI had limited success with challenging deficit models in high technology research. Rather, this case suggests very familiar patterns emerge across high and low-technology innovations. For example, concerns have been raised that social scientists are expected to act as promoters of high technology, and to explain the benefits to 'ignorant' publics, rather than acting as facilitators of inclusive and deliberative co-development between science and society (see Evans 2014; Marris 2015). The retrospective analysis discussed here, highlighted a shared assumption

across manufacturers/policy makers that end-users are ignorant of the benefits of ICS and if they could be made to understand the end benefits of this technology, they would accept it. This assumption considerably restricted the opportunity for end-users to be taken seriously and limits the ability to design cookstoves that fit with cultural contexts. In this way, engagement was a 'process of discursive exclusion' (Pansera and Owen 2018). Although the Barriers project developed some novel approaches for knowledge co-development sharing, processes of exclusion were deeply engrained and present a formidable barrier to the types of engagement imagined by RI, co-development and inclusive innovation models of innovation.

Conclusion

RI has potential to guide research on low-technology solutions to global challenges and the Barriers project provides a useful case to demonstrate RI in action that could be used to guide future approaches in similar cases. Interestingly, the analysis reveals the similarities between high- and low-technologies. There exists a pervasive 'technology developers know best' approach which relies on a knowledge-deficit understanding of the public or end-users. In other words, the public or end-users simply need to be told about the benefits of the technology because it is *better*. This top-down approach fails to understand the complex range of social, political and economic factors that shape cookstove choices. Although RI is unlikely to be a panacea for the challenges of conducting innovation research in development settings, it offers a practical framework that could help project teams identify important socio-technical elements of innovation early on in the project planning stage and as such, help project teams to work with end-users and other publics to steer research toward social needs and global challenges.

Notes

1. Found at: https://epsrc.ukri.org/index.cfm/research/framework/. Last accessed on 11/06/2018.
2. There were exceptions in 2013 and 2014 as a few partners were unable to obtain visas in time.
3. Our project partner in Kenya was also responsible for data collection in Uganda and Tanzania.
4. Our project partner in South Africa was also responsible for data collection in Mozambique.
5. Examples include NGOs, International organisations, donor organisations, local consultants, businesses etc.
6. These Bake-Off events were made possible with additional funds provided by a Nottingham University 'Discipline Bridging Award'.
7. Funds for this were obtained from a UK Engineering and Physical Sciences Research Council (EPSRC) 'Impact Acceleration' grant.
8. An online video of the Zambia cook-off can be viewed here: https://www.youtube.com/watch?v=M5S2ujl-57U.

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