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Transforming North-South research partnerships: Lessons learned from energy, technology & enterprise global challenge research fund projects

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ABSTRACT

The Global Challenges Research Fund (GCRF) provided a mechanism for academia to undertake projects relevant to the Sustainable Development Goals but there have been limited opportunities to critically interrogate such projects. In this paper we will use the Technology Implementation Model for Energy to deconstruct the purpose, assumptions and expectations, engagement strategies, and reflective processes of four GCRF projects in order to better understand relationships between researchers and those being researched. Thus, the aim of this paper is to explore and understand the lived experiences of four inter-disciplinary GCRF Primary Investigators implementing poverty alleviating technologies in a range of sectors to generate recommendations that can be applied to wider academic communities engaging with vulnerable populations.

Our key findings show that despite the integration of Theory of Change models and the Responsible Research and Innovation (RRI) framework in GCRF-funded projects, project aims continue to be driven by researchers rather than reflecting end-user needs. Whilst some projects looked to generate feelings of ownership, adequate engagement strategies and reflective learning practices, these processes are often not formally embedded in project activities resulting in a decoupling of researcher expectations and end-user assumptions – ultimately derailing project outcomes. Our recommendations for academics operating within the International Development space are to 1) Talk early, often and transparently, 2) Keep Thinking – who benefits?, 3) Be reflective, responsive, and open to change and, 4) Use a systematic approach to facilitate this process.

1. Introduction

Mechanisms for achieving the United Nations Sustainable Development Goals (SDGs) [1] are widespread and diverse in nature. Hundreds of trusts, institutions, development funds, national and international non-governmental organisations are working towards this framework for sustainable development where "no one is left behind" [1]. In the UK, the central funder for research that sits within this framework is the Global Challenges Research Fund (GCRF). Funded by the UK Government the GCRF promotes "cutting-edge research that addresses the challenges faced by developing countries" [2] through three objectives, (1) promote challenge-led disciplinary and interdisciplinary research, (2) strengthen capacity for research both in the UK and developing countries and (3) provide an agile response to emergencies where there is an urgent research need. GCRF cuts across eight UK research councils, creating opportunities to develop transdisciplinary and multi-sectoral research projects with a wide range of socio-cultural, environmental, and financial contextual factors. When conducting this piece of research in 2019, GCRF had directly funded 882 projects[1] at a cost of just over GBP800 million.[2] The GCRF projects were diverse in nature and distributed across the globe, as shown in Fig. 1. GCRF's online platform allowed easy access to Primary Investigators (PIs), as well as detailed project outlines, objectives, methods, results, and future work.

Despite the mainstreaming and theoretical integration of participatory methods, human centred design processes and conceptual models like the Responsible Research and Innovation framework (RRI) [3] and Theory of Change [4] into funds such as GCRF, there still remains a significant gap around the practical application of these models. This is

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[1] All GCRF Projects - https://gtr.ukri.org/resources/classificationprojects.html?id=D640D1B8-B141-4DFC-BCD3-CEADD848A918&type=RCUK_Programme&text=GCRF#/csvConfirm.

[2] At the time of this review in October 2019.

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particularly true in the energy sector where policy-makers, researchers and practitioners have prioritised technical performance over end-user needs and the complex socio-economic, cultural and environmental factors that underpin their willingness and ability to adopt and habitually use new energy technologies [5,6]. Reflecting this, examples of failed projects abound in the literature with technologies ranging from improved cookstoves to biogas units receiving little interest among end-users or being abandoned soon after adoption [7–10].

Concerns about this date back to Schumacher's [11] emphasis on the need for low-cost 'appropriate technology' that can be created and maintained by end-users with more recent proponents of his approach focusing on co-producing knowledge and technologies with end-users [12–15]. Important insights on addressing such challenges and negotiating underlying power dynamics within target groups as well as between key stakeholders have been provided by Chambers [16], Mohan and Stokke [17] and Buchanan [18] who encourage considerations of what meaningful engagement with target groups should look like as well as who decides what is best for them. Despite increased use of Theory of Change models that aim to work backwards from target group priorities and integrate the views of key stakeholders, initiatives that successfully negotiate unequal power relations and co-produce the complex and diverse outcomes desired by different target groups remain rare in the development sector [14].

Often when academia engage with these challenges hidden power structures are reinforced that exacerbate existing knowledge hierarchies and do little to empower research participants [19,20]. Funds like GCRF, taking funding directly from the UK Government Oversees Aid budget, could be seen to exacerbate neoliberal models of control and often lack transparency when dealing with failure and learning due to constraints within the academic funding system [21,22]; especially as many operating within academic spaces rely on knowledge hierarchies to achieve personal success. This balance of personal success versus what is best for research participants filters into ideas of how the relationship between researcher and researched, or professor and participant, can become boldly exploitative or extractive. The critical question that this research looks to explore further is, how can academia redefine this extractive relationship to enable research participants to be the protagonists of their own futures? We look to both prompt discussions around this topic and provide evidence-based strategic recommendations for alternative approaches.

The aim of this paper is to explore and understand the lived experience of four inter-disciplinary GCRF Primary Investigators (PIs) in a range of sectors implementing poverty alleviating technologies across the globe in order to generate recommendations that can be applied to research projects that work within the SDG framework. This research was part of a larger piece of work looking to determine relationships between the conceptual and practical when developing socio-technical frameworks [23] for the adoption and sustained use of energy technologies in the International Development and Humanitarian Energy sectors [6,24]. Additionally, it follows a similar methodology to that used by Hartley et al. [25] who use the RRI framework [3] as a framework for conceptual learning.

The three research objectives are:

1. to identify GCRF projects which fit the pre-determined systematic review inclusion/exclusion criteria (Section 2.1.)
2. To conduct semi-structured interviews using a phenomenological approach with the GCRF PIs framed by the Technology Implementation Model for Energy (TIME) (Section 2.2)
3. a) present key findings (Section 3) and b) a series of recommendations (Section 4) from the interviews that can be used to inform best practice for research under the SDG framework.

The structure of this paper is as follows: Section 2 draws on established methods for systematic reviews [26,27] and presents the five eligible projects, four of which progressed to the semi-structured interview stage. Additionally, we outline the Technology Implementation Model for Energy (TIME) as a framework for retrospective learning, and the qualitative methodology employed for the interviews. Section 3 presents the findings of the semi-structured interviews, whilst Section 4 generates core recommendations that can apply to the wider GCRF community. The final section, Section 5 draws key conclusions and summarises core findings.

2. Methods

2.1. A systematic review of GCRF projects

The methodology for identifying relevant GCRF projects was based upon a systematic review. Whilst originating in healthcare, systematic reviews have been used across a number of other sectors [27–29] as seen in Rehfuess et al. [30] when identifying barriers and enablers for the adoption and sustained use of a range of improved or cleaner cookstoves. Khan et al. [26] present the five steps for conducting a systematic review: framing questions for a review, identifying relevant work, accessing the quality of studies, summarising the evidence, interpreting

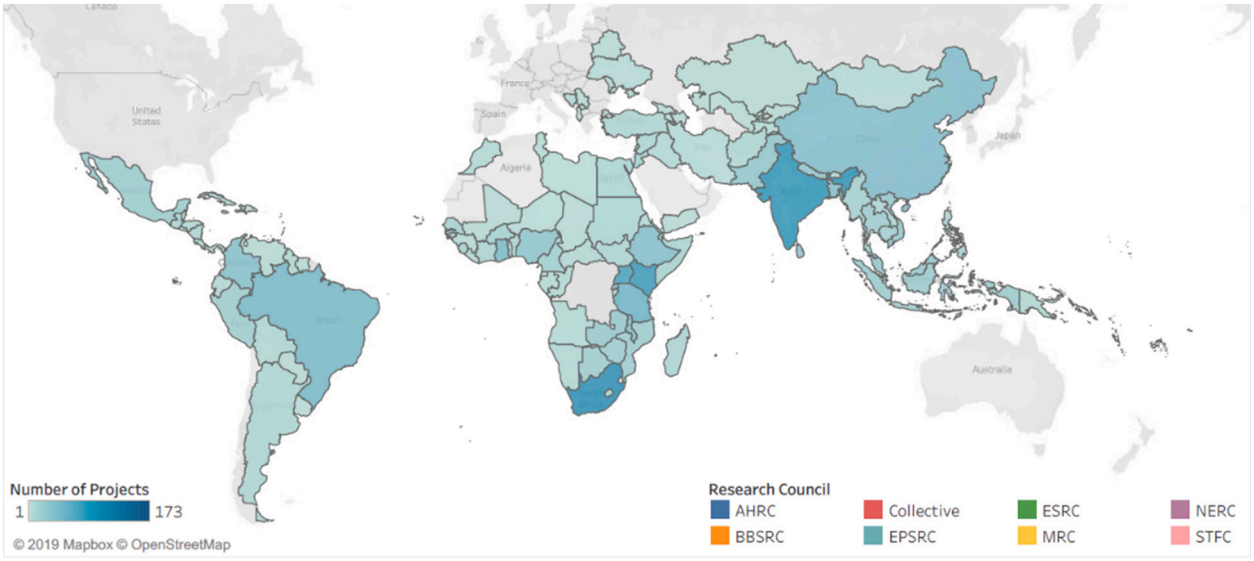

Fig. 1. Countries of focus for GCRF [2].

the findings. Torres-Carrión et al. [27] present a three step methodology which follows similar steps to Khan et al. [26].

Given the focus of the larger piece of work the adoption and sustained use of energy technologies, the inclusion/exclusion criteria for the systematic review were as follows; projects were immediately discarded if there was zero award pounds and did not align to Sustainable Development Goal 7 (SDG7) [31]. The 31 remaining projects (or 3.5 %) had a focus on sustainable energy technologies and services. Our next search criterion was "Technology AND/OR Enterprise"[3] resulting in 13 remaining projects. A detailed analysis of the published project overview, organisations, people, publications, and outcomes led to the following conclusions:

- One project was excluded as it focused on media based urban development, which was outside of the scope.
- Duplicates were identified and discarded as we were interested generating cross-sectoral insights that were applicable to a range of GCRF projects. For example, five projects considering electrical generation, distribution or connectivity were discarded.
- Two projects considered biomass energy generation; however, one reflected the government policy perspective as seen in another already selected project and was thus discarded.
- Two projects considered technology for safe drinking water. One aimed to develop low-cost technologies in collaboration with in-country NGOs and the other applied the Integrated Participatory Technology Development (iPTD) to developing a water monitoring technology. The latter project had a larger scope for community participation and was included.

A graphical representation of this process is illustrated in Fig. 2 with the project overviews contained in Table 1.

The eligible projects highlighted a range of qualitative and quantitative research methods, with budgets from £101 k to 1.71 M, across a range of geographical locations – Sub-Saharan Africa, Oceania and East Asia. Most were either developing or establishing viability for technological interventions with high-budget multi-dimensional implementation strategies utilising local partnerships to develop end-user interest.

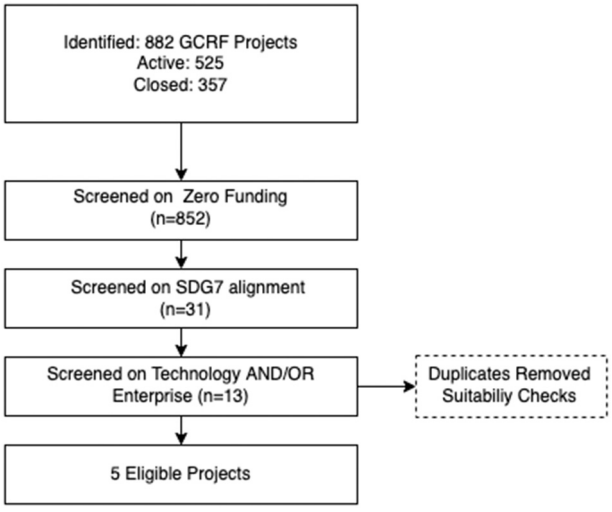

Fig. 2. Project selection flowchart.

[3] Based upon the Appropriate Technology and Social Enterprise core principles of TIME in line with the wider body of research [13,14].

Table 1
GCRF projects identified in the systematic review.

Funding org	No.	Title	Start date	Duration (months)	Award pounds	Region
BBSRC	1	Bioenergy, Fertiliser and Clean Water from Invasive Aquatic Macrophytes	31/01/2019	35	1.71 M	SSA
EPSRC	2	Sensors for clean water: a participatory approach for technology innovation	01/05/2017	35	1.18 M	Oceania
NERC	3	Implementing innovative technology to tackle barriers in utilising human waste derived fertilisers in Sub Saharan African agriculture	01/11/2017	23	101 K	SSA
EPSRC	4	TERSE: Techno-Economic framework for Resilient and Sustainable Electrification	01/05/2018	35	1.02 M	East Asia
ESRC	5	Innovation and Scale: Enhanced energy access and local market development in sub-Saharan Africa	01/09/2018	17	677 K	SSA

2.2. TIME to learn: evidencing lived experience

2.2.1. Technology implementation model for energy as a framework for evaluation

TIME as a formative and evaluative tool looks to promote best practice when conceptualising, implementing, or evaluating energy projects which have a poverty alleviating function. Its core outcome challenges the researcher "to rethink how impact is defined, to understand differences between practitioner perception and end-user reality, and to champion a co-produced approach with all key stakeholders [or project participants] in the energy system" (p.1) [24]. TIME is divided into two cyclical and interconnected elements, the central Strategic Planning Element (SPE) and the supporting Enabling Environment Matrix (EEM) as shown in Fig. 3. The SPE looks to understand the purpose & need, assumptions & expectations, engagement strategy, and any reflective practices that help close the loop of best practice, all through the lens of Co-Production. The EEM expands the engagement sub-factor to capture the roles of individual stakeholder groups and how these roles could influence the behavioural change of the intended target group through three factors deemed essential for the sustainability of project processes – Ownership, Utilisation, Equality. Additionally, TIME captures the interlevel connections across the multiple stakeholder groups (Governmental, Co-ordinating Partner, NGO/Business, Community, Personal/Interpersonal). For example, a change in government energy policy can be seen across the groupings as well as across the three core factors.

Robinson et al. [24] present the conceptualisation of TIME and outline its practical application as a framework for developing formative and evaluative approaches to energy programs in Robinson et al. [6] and Robinson et al. [32]. This paper presents a piece of the conceptual development of TIME as well as a window into the practices of the GCRF projects. As Robinson et al. [24] fully outline this conceptualisation

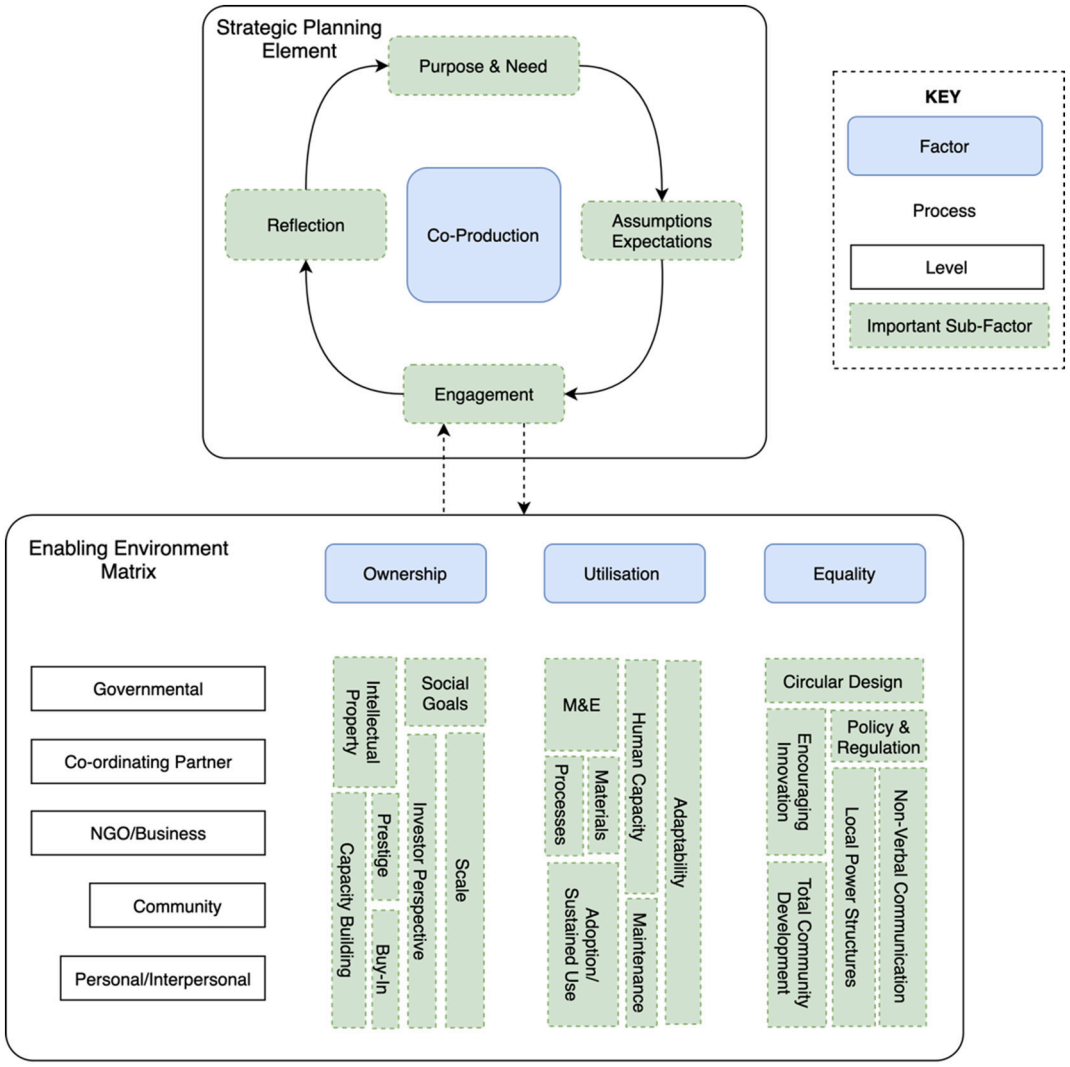

Fig. 3. The technology implementation model for energy [24].

process, in this paper the focus is on the retrospective learnings from the GCRF projects themselves.

2.2.2. *Semi-structured interviews*

In our interviews, we chose a phenomenological method as the lived experience [33] or as Arino et al. [34] state, exploring the "uniqueness of an individual's lived situation which provides a first-person point of view (p.109)" of the PIs was critical to the validity of the retrospective learning process. Hence, between October – December 2019 the lead author conducted four interviews (from the five eligible projects) with GCRF PIs where each interview lasted between 45 and 90 mins. The PIs were the key decision makers in the project processes which allowed insights to be generated from the perspective of researchers in line with our phenological methodology. We recognise that not conducting interviews with other project participants (such as end-users) is a key limitation of this methodology and would provide a valuable next step when conducting future research.

2.2.2.1. Data collection. The semi-structured interviews were structured in line with the TIME framework, however, as stated by Kielmann et al. [35], the interview guide is not a survey questionnaire and the discussion was led by the participant with the interviewer following up on specific topics relevant to the study. The interviews were structured in three distinct sections, starting with an introduction into background of the GCRF project and its positioning in the International Development Sector. The first question "can you tell me about your GCRF project and your role in it?" was designed to 'break the ice' and allow the PI to feel comfortable talking about their project. However, in a number of interviews this question received long answers that had little relevance to the subject and required careful redirection to our central topics of discussion. The second segment was designed to determine the key project levels/factors from the perspective of the PI and which of these levels/factors the GCRF project was most engaged in. We then asked direct questions about the importance of these factors or themes in determining the success or failure of their project, as well as what they thought were the most important for the project. The segment section gave the PIs the opportunity to mention anything else they felt was important or any other questions they had for the interviewer. It is worth noting that due to the small number of interviews we did not expect to reach theoretical saturation for the data [36].

2.2.2.2. Data analysis. Using the software package Nvivo [37], and echoing the multi-level analysis approach set out by Ribeiro et al. [38], we coded our transcripts into a coding framework guided by the structured approach of TIME (see Robinson et al. [6] for example). First, the lead author coded the nodes determined by the level/factors/sub-factors in the SPE and EEM, second, we considered the transcripts from the perspective of the nodes, refining and recoding the data ensuring that

any duplications were removed. This resulted in a matrix of supporting quotes where each coding point within the node represents a single project narrative point made by the interviewee. This meant that if the interviewee made 5 points about ownership on a community level there would be 5 quotes in the [community, ownership] EEM; allowing the researcher to see the distribution of talking points across the interview series. This allowed analysis of both what was discussed, what was not, what was important, and what was not, all through the perspective of the PI.

2.2.2.3. Limitations. As with any research approach, qualitative methods have a number of limitations or criticisms which are important to recognise. Bryman [36] cites four main areas: the subjective nature of qualitative research, the difficulty of replicating results, problems of generalisation, and a lack of transparency. Whilst this section has set out a detailed operational qualitative methodology that supports our research outcomes, in reality this process may not be linear. Our data collection and analysis occurred concurrently, allowing for modification of the methods, to mitigate issues of replicating results, as the study progressed with the quality of data increasing as the process was repeated. We recognise this processes as a way to increase the transparency of the work and acknowledge any resulting bias that may have occurred due to researcher positionality [39]. John [40] discusses quantitative research methods as an incremental solving of the question, one step at a time with a number of blind alleys. This can also be applied to qualitative methods, and we recognise that there may be unplanned and unpredictable parts to the data collection and analysis which may lead to novel discoveries throughout the processes. The flexibility of approach, which helps mitigate the problems of generalisation, is also echoed by Mack et al. [41] who state that "qualitative methods are typically more flexible – that is, they allow greater spontaneity and adaptation of the interaction between the researcher and the study participant." Finally, we acknowledge the small number of interviews conducted as a potential limitation as it could narrow the scope of our results.

3. Key findings: evidencing lived experience for retrospective learning

This section presents the key findings from the semi-structured interviews as coded into the TIME framework. We present the results across the four key sub-factors contained within the SPE. Additionally, we interrogate the engagement factor through the enabling environment matrix to better understand the interactions between key stakeholders across the main project levels; all with the aim of generating universally applicable recommendations for GCRF PIs to conduct more effect research processes and generate results with greater end-user focussed impacts.

3.1. Purpose

The discussions around purpose focused on several questions; What is the project trying to achieve? Where did the idea originate? Is the project driven by the researchers or participants (primarily partners and end-users)? The responses from our four PIs were as follows:

> "Before we applied for any money we managed to get some pump priming to go to Vanuatu and start engaging with communities over there and trying to scope what the big challenges were facing them […] so that's why we are looking at water and water quality because that is what the communities wanted"
>
> (PI2)

> "We were trying to develop an infield tool that can be used by small order farmers to determine the nutrient content of their soil and also of organic amendments"
>
> (PI3)

> "We have got the engineers modelling for landslides and earthquakes. And a social science element of it which comes from the recognition that you can have technical expertise but unless you get down and talk to people, all the models might be correct but none of them might work when you go to implement them in the field. We are currently working on a project which is basically sustainable electrification in rural communities."
>
> (PI4)

> "We basically want to understand, or that was the original idea of the project, what are the obstacles and opportunities for electrification in Africa"
>
> (PI5)

As can be seen in the quotes, the clarity of purpose differs between projects. For example, PI2 talks generally about water and water quality, whilst PI3 talks of a specific tool and accompanying methodology. The projects with greater clarity of purpose tended to have a more direct approach to meet their research aims and needs (independent of who decides these aims and needs). PI2 & PI5 co-produced their purpose with project participants, especially wanting to engage end-users at an early stage in the research process. PI3 had the opposite approach, applying a technology designed for/developed in the UK to Ghana and Kenya consulting the users on suitability only. PI4's approach lay somewhere in the middle as they were asked to complete the research by a national government but co-produced policy recommendations as well as integrating social factors (derived from semi-structured interviews) into their electrification model. Thus, there was a direct link between clarity of aims, level of end-user participation, and perception of project success.

3.2. Assumptions and expectations

Expectations are traditionally based on our own life experience, "a belief that something will happen because it is likely" [42] whereas assumptions are based on "a belief or feeling that something is true or that something will happen, although there is no proof" [42]. In this section we interrogate the assumptions of the PIs and the expectations of the end-users. PI assumptions broadly covered a range of issues around the type of technologies needed, the accuracy and cost of technologies, and financial factors, project life cycle and management. When working within the GCRF mandate with low-income and often marginalised communities the assumptions that are specifically relevant to this case are about end-user needs, suitability or appropriateness of technology, socio-cultural norms, community resilience, willingness, and if a 'westernised' approach would work in a low-income context. The quote below from PI3 illustrates an assumption the PI had made about the socio-cultural norms of their participants:

> "[we were doing] field trials with tomatoes and I was very concerned that, because these are not in fields with barbed wire, people would vandalise, steal and take the tomatoes so that we wouldn't have any data. But that was really not the problem, I was completely misled, because nobody came anywhere near it because it was applied with FDF [Faecal derived fertiliser]. We were very keen to give some to the farmer for free as he has been helping me and he said no, I won't have any because my wife won't allow me, she won't have those vegetables in the house […] we have even been told there are evil spirits dwelling in this produce"
>
> (PI3)

When researchers (or key decision makers) do not moderate expectations effectively, assumptions made by the technology end-users can destabilise project outcomes. As identified in the wider literature this misalignment of priorities can result in the failure of energy technology for poverty-alleviation projects [24,43,44]. This process was illustrated

by PI4, "in the future it's going to be a risk between a political and social buy-in as communities are not getting what they think they've been promised, and the government can't actually provide what they promised." This managing of expectations and the failure to mitigate against different expectations was also explained in PI5:

> "[energy companies] are not aware of the community needs to a large extent. They don't explain their solution enough, so there is a big gap between the perception of the community of the solution and the perception the developer has. One example is a few sellers do a solar home system on a pay as you go basis […] and if they don't pay, then they get switched off and the community members often don't understand why this is the case so they get really mad or they are trying to hack the system to get more electricity out of it" (PI5).

PI2 recognised the disconnect between PI assumptions and the expectations of the focus communities, "We had a few ideas about the sort of technologies that we work on and what we think we could do but we wanted to be sure we were addressing a real need in Vanuatu" (PI2). This resulted in moderated expectations for both the researcher and the end-users. As neither had an unrealistic or uninformed expectation, this resulted in the alignment of end-user and researcher priorities.

However, across the GCRF projects there was a lack of a systematic approach to understanding and deconstructing user expectations. Whilst some projects grappled with ideas such as who owned the final technological solution (in PI2 this was set out in a Memorandum of Understanding), others emphasised that these expectations must be available in a local, understandable language or communicated through pictorial format. PI4 states that "instructions on [the solar panels] are in English which is interesting because lots of people didn't speak English and lots of people couldn't even read so again, there is a lack of foresight on the part of the government and the implementing partner". Methods of aligning assumptions and expectations links closely to the chosen methods of engagement and are explored further in the EEM.

3.3. Engagement (through the EEM)

A central element of any project working in the socio-technical domain is engaging with relevant key stakeholders across the project cycle, be that in promoting ownership through participation or utilising existing socio-cultural systems and processes to increase project efficiency. TIME meets this engagement process through its three core factors, Ownership, Utilisation and Equality. The overarching theme from the semi-structured interviews was that projects which were more market orientated focussed on the ownership factor, whereas more traditional top-down charity focussed projects emphasised equality. The use of local resources (both in systems and materials) depended on the appetite of the PI for long term change due to the difficulty of establishing local technology mechanisms rather than simply importing technologies from the UK. Fig. 4 acts as a visual summary of the data to show the distribution of the individual levels and how the three core-factors interact with the individual levels.

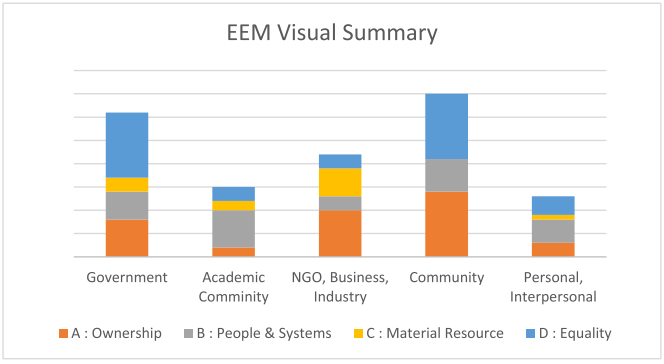

Fig. 4. EEM visual summary.

Whilst we recognise that it is of central importance to engage with all key stakeholders, PIs looked to prioritise engagement activities that would generate maximum outputs. The dominating level was community as the target group of all the projects were communities. This was predicted as all GCRF projects focused on solving global challenges in low-income areas in accordance with the GCRF goals and many low-income households are located in rural communities due to the limited work opportunities. This is broadly reinforced by Fig. 5 which depicts a word cloud analysis of the interview transcripts. The word communities (and similar words) were used 1.53 times more than the next most frequent word. Additionally, given the beneficiary centred approach that the theoretical framework looks to employ, placing the community at the centre is an important methodological step independent of the implementation model used. Conversely, there is a lack of data and interest from PIs on the personal or interpersonal level. The selection of GCRF projects were keen to engage communities as an entity but did not look to understand deeper personal or interpersonal connections between the actual end-users or wider community members. The main challenge stated when engaging individuals was the time required to complete individual interviews whereas as focus groups provide a quick community group consensus. However, focus groups are well documented as having the potential of misrepresenting personal opinions as the loudest individuals can dominate and the most marginalised members do not express their views [45–47]. Individual interviews also require, in most cases, time to build an open and trusting relationship between interviewer and interviewee to negate the issues associated with outsider status, positionality and bias, especially as the researchers often live in Europe and the researched do not. When considering the relationship between the community and academic levels, more academic involvement in a project resulted in less community involvement which represents traditional power structures in academia where academics act as the primary decision makers as they play the central facilitating role.

Second to community was the NGO, Business & Industry Level, where partnerships are key to project success. This result was due to the co-produced technology implementation mechanisms with local in-country partners. These GCRF projects look, to varying degrees, to utilise existing systems, materials and local contextual knowledge to allow the researcher (or project manager) to use funding more effectively.

The least important level to PIs was Local and National

Fig. 5. WordCloud analysis of all transcripts.

Governments. The role of local and national Government throughout these GCRF projects was in creating and providing the systems within which the project exists, be it indirectly through a regulatory framework that encouraged innovation or directly through subsidies for the technology itself. Whilst some projects interacted directly at a government policy level, others were just recipients of policy decisions. For example, PI4 was asked by the government to create a model for rural electrification but was not consulted in the decision-making process which resulted in a misalignment of government and end-user priorities. However, PI4 did not feel they could inform the government of this mismatch in priorities as they were only an implementation partner and the payment for work was dependant on the completion of the outputs. This traditionally top-down model, where information travels unidirectionally from top to bottom resulting into no inter-level interactions, resulted, in this case, in the exclusion of end-user priorities, which we have already identified as key for project sustainability. There is capacity for larger government involvement if the outcomes are co-produced with community representatives and this mismatch of proprieties is identified and modified accordingly.

3.3.1. Ownership

The distribution of the *Ownership* factor mirrored the general trends (seen in Fig. 4) with the Community/NGO, Business & Industry/Government levels representing the majority of project focus.

Tools to Engage with Users and create a sense of ownership: A number of tools emerged from the interviews that help facilitate this engagement process. PI2 facilitated a bricolage process [48], that they defined as:

> "Bricolage basically means rather than going in with a concept of what the structure should be like, be that a committee, we go into communities and allow them to design the structures themselves based on their knowledge of what does work and what doesn't work in communities."
>
> (PI2)

The process was conducted through a series of multi-stakeholder workshops aimed at bringing together various key stakeholders (communities, NGOs and local/national government). Moreover, the workshop format captures and manages the expectations of the stakeholders. However, the presence of these stakeholders in the same physical space did not mean there was a willingness to collaborate. Engagement thus became a co-produced activity where engagement is required across project participants for the process to be successful. The facilitation of workshops between key stakeholders is a common process for information gathering however, it only featured in one other project, PI5:

> "we performed around 50 interviews with policy makers, NGOs but we also included the business to get an understanding of their priorities with regards to energy in general, we wanted to find out if there were any conflicts between the institutions, we wanted to see if there were any gaps, so basically how can we achieve regulatory and policy framework that enables off-grid electrification and where are the gaps right now"
>
> (PI5)

This was paired with over 1000 quantitative surveys resulting in a comprehensive data set for understanding energy usage. Similar to PI2, PI5 facilitated interlevel conversations to enable future facing collaborative processes. The engagement factor was summarised well by PI5:

> "We all have this wonderful idea that we are constantly in touch and everything is wonderful in the community because you have long standing co-operation and communication but, in the end, how manageable is that. Especially if you scale your business"
>
> (PI5)

The timing of engaging project participants is critical in technology adoption. Often the "when" of engagement is of equal importance to the "why". PI2 co-produced the project outcomes at the beginning of the project cycle, creating a greater understanding of what the communities really needed. However, this level of engagement can lead to other problems such as, who owns the technology after the project is completed. PI4 further reinforced the "when" of engagement with another example of government engaging too late with communities which led to a lack of buy-in, interest and ultimately abandoning the implemented technology.

> "I think there is a slight power and perspective issue because of what's been delivered by the government, it doesn't actually meet the needs of the community […] I think also it's not just about the negotiating and the design it's also about ownership and making sure that there is ownership that builds legitimacy and long-term connection with whatever it is that you are trying to do"
>
> (PI4)

PI3 also faced this problem to a great extent where the fundamental project purpose was questioned by the target group of their research:

> "Upon engaging the farmers, we said that we were only interested in nitrate, but they said they were interested in phosphate and potassium, but the paper strips we have found for potassium and phosphorous don't really lend themselves"
>
> (PI3)

3.3.2. Utilisation

Utilisation is divided into two sub-factors – the utilisation of systems & processes, and utilisation of material resources (generally the technology itself or the raw materials needed to manufacture the technology).

The utilisation of systems & processes is based upon using existing networks, systems and processes to increase the efficiency of the project; for example, using a farm extension worker in Kenya to facilitate the relationship between the academic community and community levels as in PI3. As the nature of the GCRF projects are research based much of the utilisation of human resources is through the academic network created by the individual PI. The expectation was that the community level would dominate this sub-factor however the NGO, Business & Industry and government levels also showed a number of interactions. The implication is that for larger projects, such as these GCRF projects, it is important to engage key stakeholders who have the ability to operate across multiple levels as this mitigates problems associated with knowledge hierarchies and propagating an extractive research process:

> "we felt that it's not for foreign scientists to come and tell them how good this [technology] is, because many foreign scientists do that. If you want to be really effective you have got to work with the people, especially through the extension workers"
>
> (PI2)

As shown in the data, maintenance and the ongoing cost of technology use was not widely considered by the interviewees. This was possibly due to the structure of the research and the funding; it becomes difficult to convince a community to be part of a pilot if maintenance costs are required after the end of the pilot.

When considering the utilisation of local materials, surprisingly, the majority of PIs did not consider using materials that were already at the GCRF project sites. This was either due to technologies, such as the paper strip (PI3), not being readily available or the complexity of the technology being too great for local manufacturing capacity, such as the solar cells (PI4/PI5). This provides a major area of concern where technologies are designed in a laboratory environment and expected to be successful in a low-income environment in spite of local processes and systems.

3.3.3. Equality

The final factor to analyse is *Equality*. Equality refers to not only societal equality, through the fair treatment of political and cultural minorities, but the equitable design of technologies throughout the product lifecycle as seen in conceptualisations of the Circular Economy [49]. Equality also deals directly with power structures in the project context. The PIs shared the understanding that it is not appropriate to actively disrupt local systems, "Our position was not necessarily to disrupt [the local power structures] but we also didn't shy away from them. By breaking them [the participants] into groups and bringing them back together in some way you are highlighting the differences in the community" (PI2). Equality also considers how you communicate with verbal and/or non-verbal communication methods. This connects to the qualitative research literature where there are many different methodologies concerned with appropriate inclusion [35,41,50]. However, whilst all PIs understood the importance of this dimension, the formally embedded mechanisms (such as Theory of Change and RRI framework) that ensure the equality of process were strangely absent from the discussions hence the limited data in this factor.

3.4. Reflection

Reflective practices close the loop of co-production and act as a critical process in accounting for spaciotemporal variations in implementation contexts which have the power to derail core project activities. In the context of TIME, the reflection sub-factor enables an iterative or cyclical relationship between the co-production sub-factors. This is illustrated through all the GCRF projects modifying engagement strategies based on the specific socio-techno-economic context, redefining the research objectives (purpose and need) as well as identifying what went well and where the areas of improvement lay.

> "We then went back to the communities and told them what we could achieve and what we couldn't achieve, again having the discussion thinking about those things that are critical and those things that are less critical"
>
> (PI2)

As illustrated by the interviews reflective learning practices are often not formally embedded in project activities resulting in limited data points for this sub-factor. However, all PIs stressed the importance of this process, even if only conducted informally and at the time of the interviews.

4. Recommendations

TIME looks to promote general best practice when conceptualising, implementing or evaluating projects [24]. In this section we look to draw specific recommendations generated from the semi-structured interviews that can enable current and future GCRF projects to more effectively and efficiently align project processes to their own definitions of success.

4.1. Talk early, talk often, talk transparent

The interviews showed that developing early consultations (preferable pre-funding) with focus communities about setting realistic outputs based on the needs of the target groups and providing time to develop meaningful (trusting and equitable) relationships is essential. Moreover, as shown in this paper, the "when" of engagement is of equal importance to the "why". The late application of a systematic approach for interrogating assumptions made by researchers and the expectations of the target group causes significant issues with project viability. The "who" researchers talk to is also significant and it's crucial to engage project participants who have the ability to operate across multiple levels to achieve multi-level change. Finally, in all these conversations and consultations it's critical to be transparent with all partners and effectively communicate all aims and intentions otherwise focus may be lost on who may actually benefit from this work.

4.2. Keep thinking – who benefits?

The core outcome of this paper is to persuade the reader that academic research projects working within the SDG framework need to rethink power structures between the researcher and the researched. There is a need to redefine the research process when working with marginalised groups, to better understand how can benefits can be meaningfully shared with a clearer understanding of who should decide what those benefits are [16,51]. Often, PIs are not contextual experts on their project topic which had led to the partnership models encouraged by GCRF. However, as outlined by our interviews the power dynamics in these partnerships are not deemed equitable due to constraints set by the funder. This raises the question, can thermatic experts (such as the PIs) ever understand the contextual needs of their target groups?

PIs did look to give away decision making power (as most important level to the PIs in community) however, more academic community involvement in a project often resulted in less community involvement as there was a direct link between clarity of aims, level of end-user participation, and perception of project success. One route to achieving this redefinition of roles is localisation as seen in the humanitarian sector [52,53] (as outlined by the Grand Bargain [54]) where 25 % of project funds are paid to in-country project partners to initiate handing key decisions over to local partners through their systems and process. Whilst this does not guarantee that end-user priorities would be embedded in project processes, it is a step towards this process. But perhaps this is a step to far as the arguably simpler task of using the materials that were already at the GCRF project sites was not widely considered in the interviews.

4.3. Be reflective, be responsive, be open to change

Despite the emphasis placed in GCRF funding applications on co-developing a theory of change [55] and working within RRI [3], across our interviews we identified a lack of systematic approaches to understanding and deconstructing user expectations through the lens of co-production. The lack of alignment between researcher assumptions and participant (and more specifically end-user) expectations can destabilise project outcomes, especially given the spaciotemporal variations in end-user needs due to changing contexts. This leads to the more general realisation that reflective learning practices are often not formally embedded in these GCRF project activities. Reacting to changing user needs is a critical element of successful project management in the international development space, yet the constraints placed on the PIs by the GCRF reporting processes were not open to the changing needs of end-user or target groups.

4.4. Use a systematic approach to facilitate this process

Finally, as the research area of creating systematic approaches to energy methods evolves and builds a cross-disciplinary and intersectoral narrative, the case for using tools such as TIME strengthens. By critically interrogating themes such as Purpose & Need, Assumptions & Expectations, Engagement, and Reflective practices at the conceptualisation stage many of these GCRF projects would have identified the key risk areas in implementing these poverty alleviating technologies and avoided some of the pitfalls.

5. Conclusion

In this paper we set out to explore and understand the lived experience of five inter-disciplinary GCRF Primary Investigators (PIs) in a range of sectors implementing poverty alleviating technologies across the globe in order to generate recommendations that can be applied to

the wider GCRF community. First, to satisfy RO1, we conducted a systematic review of 882 GCRF projects using the inclusion/exclusion criteria of zero award pounds, SDG7 alignment, technology AND/OR enterprise and through removing duplicates and unsuitable technologies identified 5 suitable projects – four of which were open to discussing their projects. Then, in line with RO2, conducted these interviews using a qualitative phenomenological approach and identified common themes using TIME as a coding framework in Nvivo 12 [37].

These interviews showed a diverse range of strategies, methodologies, tactics and management styles when working within the remit of GCRF. Our key findings, framed by the TIME framework showed that when engaging with the Purpose & Need subfactor our PI's had to balance their own wishes and aims with the aims of their participants as there was a direct link between clarity of aims, level of end-user participation, and perception of project success. If PIs closely controlled this process, based upon their own desires, they often fell short of their own measures of success compared to projects which co-produced their purpose and needs with the focus communities. This is despite GCRF projects presenting some form of Theory of Change at the funding application stage. We identified a range of researcher assumptions around participant (specifically end-user) needs, suitability or appropriateness of technology, socio-cultural norms, community resilience, and willingness to adopt new technologies. However, these assumptions were often not matched with end-user expectations of what would be delivered. This process of not moderating expectations effectively was primarily due to the lack of a systematic approach to understanding and deconstructing user expectations, despite these mechanisms (Theory of Change) being included in the GCRF framework of work.

Next, we interrogated methods of engagement through the lens of ownership, utilisation and equality. Whilst PIs were focussed on the community level they often did not interact with individuals (even through their in-country partner organisations) from these communities due to time and logistical constraints and the majority overlooked the national and governmental levels. This may hint at a deeper problem around the difficulties of accessing more marginalised groups and trying to ensure benefits do not get co-opted by those with more power and influence. There were a number of tools, such as multi-stakeholder workshops, to engage with end-users and create a sense of ownership however the PIs stressed the "when" of engagement is of equal importance to the "why", as if these groups are engaged too late the process of co-production can significantly destabilise intended project outcomes. PIs did look to employ local community members for the dissemination of project information but did not step past this step and utilise the full range people & systems to intergrade project process with socio-cultural norms, despite GCRF projects all having in-country partners. To close the loop of co-produced best practice, we showed that reflective learning practices are often not formally embedded in project activities which leads to limited opportunities for end-user or focus communities to reshape the project outcomes based on their changing and evolving needs.

Finally, these key learning translated to (RO3b) a series of recommendations that can be used to inform methods of best practice across academic research projects working within the SDG framework. These include; 1) Talk early, talk often, talk transparent, 2) Keep thinking – who benefits?, 3) Be reflective, be responsive, be open to change and, 4) Use a systematic approach to facilitate this process. We recognise that this paper does not provide all the answers to re-defining the relationship between researcher and researched or professor and participant, however we look to initiate the discussion, and bring attention to issues that are often overlooked by organisations, who bridge the academic and International Development sectors, when choosing who and what to fund.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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