Opening up Responsible Research and Innovation: Learning from human and more-than-human knowledge-holders

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Abstract

Responsible research and innovation (RRI) is increasingly being implemented by researchers, and in the UK, its use is encouraged by funders such as UK Research and Innovation (UKRI). The aim of RRI is to ensure that research and its impacts are opened up to broader deliberation, engagement and debate in an inclusive manner, and to enable the complexities and uncertainties of research to be revealed through involvement with those impacted by the research. Taken at face value, RRI appears to challenge the status quo of decisions around scientific and technological developments being left to those with scientific expertise. However, existing RRI frameworks are anthropocentric, and exclude the more-than-human world (animals, plants, soil, water, land etc.,). To address these issues a project was undertaken which aimed to design, co-produce and provide a conceptual framework for including the more-than-human world within responsible research and innovation. Part of the project included a one-day in-person workshop with diverse knowledge-holders to ensure different knowledges and perspectives were feeding into the project. The focus of this article is not on the workshop itself, but what arose from it. Following the workshop, one of the knowledge-holders produced a written piece about game theory and its potential role in RRI. This written piece is presented here and its importance and relevance to RRI is reflected upon. We explain why this written piece about game theory matters to RRI. We conclude by offering recommendations to researchers.

Keywords: responsible research and innovation; RRI; more-than-human; game theory; politics; frameworks; knowledge-holders

Responsible research and innovation (RRI) and the more-than-human

Science and technology is being developed to address numerous environmental challenges including climate change and biodiversity loss. Responsible research and innovation (RRI) is increasingly being implemented by researchers to ensure that research and its impacts are opened up to broader deliberation, engagement and debate in an inclusive manner, and to enable the complexities and uncertainties of research to be revealed through involvement with those impacted by the research. RRI acknowledges that innovation can be unpredictable as well as beneficial and can raise questions or concerns. The definition of Responsible Research and Innovation offered by von Schomberg is:

> *Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society). von Schomberg* (**2011: 47**)

However, a broader definition of Responsible Research and Innovation is offered by Stilgoe et al. (**2013: 1570**): 'Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present'. This definition underpins the RRI framework developed by Stilgoe et al. (**2013**), which has been adopted in the UK by UK Research and Innovation (UKRI), and in particular, the Engineering and Physical Sciences Research Council (EPSRC). The AREA framework that the EPSRC promotes consists of four dimensions and these are:

Anticipate – describing and analysing the impacts, intended or otherwise.

Reflect – reflecting on the purposes of, motivations for and potential implications of the research.

Engage – opening up such visions, impacts and questioning to broader deliberation, dialogue, engagement and debate in an inclusive way.

Act – using these processes to influence the direction and trajectory of the research and innovation process itself. (**adapted from EPSRC, 2024**)

Taken at face value, RRI appears to challenge the status quo of decisions around scientific and technological developments being left to those with scientific expertise. Alternative knowledges can act in partnership with scientific knowledge and expertise, breaking down social hierarchies.

However, existing RRI frameworks are anthropocentric, and exclude the more-than-human world (animals, plants, soil, water, land etc.,). Without including the more-than-human world in RRI frameworks, environmental crises such as climate change and biodiversity loss will never be able to be fully addressed as key knowledge-holders are omitted.

To address these issues, a project was undertaken which aimed to design, co-produce and provide a conceptual framework for including the more-than-human world within responsible research and innovation (RRI). To provide context, we are: Catherine Price, an environmental social scientist, and Tom Bott, a soil scientist and microbiologist. In this project, we started out defining the more-than-human as 'non-human agents, technologically mediated elements, Earth-others (land, waters, plants, animals) and non-human inorganic agents (plastic buckets, wires, software, algorithms, etc.,)' (**Braidotti, 2019: 164**). This transdisciplinary project attempted to show how environmental challenges could be addressed whilst also affecting positive change. This was achieved by engaging with the under-valued voices and agencies of alternative expertise (human and non-human) alongside scientific knowledge and understandings. To test the suitability and further its development, the conceptual framework was applied to the case study of biochar. Biochar is a carbon-rich material produced when biomass undergoes a thermochemical process called pyrolysis. Biochar is an ideal case study as it is a 'new technology' that is currently being investigated for its greenhouse gas removal potential at scale and which has a direct impact on the more-than-human world throughout its lifecycle.

Part of the project included a one-day in-person workshop with diverse knowledge-holders to ensure different knowledges and perspectives were feeding into the project. The focus of this article is not on the workshop itself, but what arose from it. However, some details of the workshop are provided for context: 15 knowledge-holders participated in the workshop (**Figure 1**), and a deliberative focus group approach was used. All knowledge-holders acted as co-producers of knowledge. Three activities were conducted during the workshop. We asked our knowledge-holders to consider:

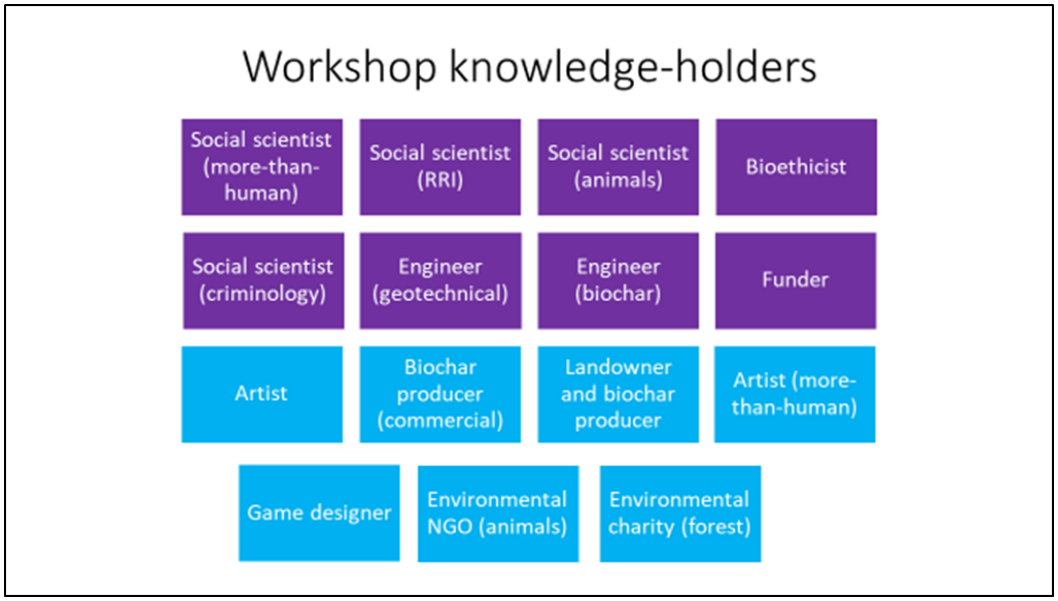
1) The more-than-human – is there a better term?

2) Does the existing AREA framework work for the more-than-human

3) What needs to be included in a revised RRI framework, and who are knowledge-holders?

It is the final activity that is most pertinent to this article.

Figure 1: Knowledge-holders who attended the workshop.
Knowledge-holders in purple are academics and knowledge-holders in blue are non-academics.



Once each activity was completed in small groups, our knowledge-holders reported back to the full group. During the discussion for Activity 3, one of our knowledge-holders discussed game theory and how this could help include the more-than-human world in RRI. Following the workshop, they went away and considered game theory further. The result was a written piece by Min Burdett, the landowner/biochar producer knowledge-holder, and this is presented in the next section.

Game Theory and More-Than-Human Considerations – by Min Burdett

Following a workshop at Nottingham University on 'Including the More-Than-Human World in Responsible Research and Innovation (RRI): Developing a Conceptual Framework', this note aims to expand on my suggestion that game theory is a useful consideration. It is written on the basis that More-than-Human should focus on our natural environment. It considers that human artefacts, such as pre-activated biochar, buckets and mobile phones, are tools which humans use, but are not capable of independent participation in the game.

The natural environment that we live in is a finite resource shared by the world population. As we may be headed towards the Sixth Extinction, we are realising that we have to manage our environment better. Aristotle observed that in our competition for natural resources, humans are not inclined to protect. He wrote 'That which is common to the greatest number gets the least amount of care. Man pays most attention to what is his own: he cares less for what is common.' I suggest game theory and

more recent related developments such as complexity theory, all referred to as 'GT' below, could usefully contribute to the project.

GT is an attempt to show the differing, possibly conflicting, needs of the parties and estimate how to reach the best outcome for some, possibly all, parties. Economic agents are typically human, and typically, GT is used to analyse competition versus cooperation where cooperation results in a better outcome for the individuals. This cooperation may be forced (e.g., by rules of the game) or, in the repeated games, derived from knowledge gained about the competitors' strategy.

GT forces us to analyse the parties involved, their interests and changes to those interests over time. Describing the strategies used by the players to interact with each other at an early stage of research would help researchers and their sponsors to understand the wider implications of the area of study. If required at a later stage, researchers may introduce a numerical foundation which reflects the strategies and helps model the areas of uncertainty. GT is now widely implemented in software, so comparing developing scenarios is less onerous than in the past.

GT has a pedigree going all the way back to the 1920s. It has evolved and been used successfully in many areas, including economics, military strategy (it was reputedly used in the Cuban missile crisis), the UK mobile network licence auction, cybersecurity, fishery policy and evolutionary theory, to name only a few. It continues to be developed. One related field, complexity theory (with its emphasis on adaptive behaviour, emergent properties and minor variations causing massive changes) has been used in ecology and immunology[1].

Can we use game theory to support the analysis of the interaction between humans and the natural environment? To do this, we would have to assume that the natural environment (or different elements of it) are players and have their own game strategies which help the environment react to what the human players do. The emphasis here is that the natural environment is a player of equal importance to the different human participants rather than an outcome of the game. In May 2022, the UK Greenhouse Gas Removal Event was held. This event was jointly organised by two major UKRI funded GGR research programmes, the Greenhouse Gas Removal Programme and the Greenhouse Gas Removal Demonstrators Programme. The event showcased the latest GGR research and innovation. One of the conclusions from this event was that the five Demonstrator studies (biochar, enhanced rock weathering, peatland restoration, perennial biomass crops, and woodland creation and management) given all their solutions were land-based, should put more

[1] See https://www.youtube.com/watch?v=iZKErrvVMaY for an explanatory example

consideration on the impact on the natural environment. The natural environment was an afterthought, not a player. For the future it must be a player.

Taking the Biochar Demonstrator as an example, how could game theory have been used? First of all we would need to define the game. It is complicated and needs some deconstruction. Looking at the biochar lifecycle, there are three elements to it: biomass sourcing (wood, agricultural residue etc.,); biochar production (technology, location, co-products such as biofuels, heat and pollutants); and product use (impact on soils; direct application vs pre-application activation; alternative non-agricultural uses) etc.

Each of these elements of the game has an environmental impact. For example, there will be competition for the finite resources of biomass sourcing. Focussing on trees without consideration of the natural environment, the game may quickly lead to fast growing, easily harvested, monoculture sources, leading to competition for biofuels and land usage. With the natural environment as a player (a proxy for this might be the UK Government's English Land Management Scheme (ELMs) objectives of improved air, water and soil quality, increased biodiversity, and climate change mitigation), the game may lead to sourcing from better managed existing woodlands and the new plantations already being implemented to meet the ELMs objectives.

For the natural environment to participate, the players or game's rule makers will have to make a judgement about its importance. In our biochar sourcing example, the landowners, once they understand the impact on the environment, may choose to follow an environmentally friendly path. If not, the rule makers may have to incentivise and/or regulate to steer the game to the desired outcome.

We saw at the workshop the power of an interdisciplinary group coming together to develop a research subject. Implementing a GT based approach including the natural environment as a player requires us to consider the environment at the earliest stages: who are the environmental players and how will they interact with the human ones. One participant at the workshop suggested that there should be an iterative approach to responsible research whereby the original research specification was revisited during the research programme and adjusted in light of what had been learnt. A GT approach supports this suggestion. Throughout the research process another round of the game can be played: have we identified all the participants; have we correctly assessed how they will react to the other players; have we considered changes to players' interests over time?

I also suggested that the approach should be fun! I meant this in the sense that the workshop was fun. The generation of ideas from a group emanating from disparate backgrounds and disciplines coming together to address an issue should be part of the conceptual framework. In a GT workshop, stakeholder representatives would need to develop their understanding of the subject area from other players' viewpoints and discover how to modify their behaviour to cooperate with them for a mutually beneficial outcome. The participants would not only be imparting their expertise but broadening their understanding and knowledge contacts.

Research Impact (for the Project)

This written piece was not an invited contribution, rather the result of deliberation and reflection of someone the project had engaged with. For us, as the researchers involved with the project, the piece opened a new point of deliberation and discussion which could be used in further work and research. Furthermore, the approach of game theory potentially opens new ways of interacting with knowledge-holders in future workshop sessions. Overall, this short piece has the opportunity to alter the direction of research within this project and for future research.

Why this Written Piece about Game Theory matters

More broadly, this written piece about game theory is hugely important because it is written by a non-academic knowledge-holder. It is significant to not only developing RRI to include the more-than-human world, but it also contributes to our understanding of how knowledge-holders could be included in RRI. Min Burdett chose to go away and write this piece. There was no requirement to do so. If, as researchers, we give knowledge-holders the opportunity to engage with our research, then there is the potential for new ideas and an open discussion about new scientific and technological developments. Whilst this is only one example, and we cannot generalise, this written piece shows a willingness by knowledge-holders to contribute to our projects as invested participants. It also highlights that RRI can work as envisaged.

What this means for the AREA framework

Within the AREA framework, the dimension the written piece fits within is *Engage*. As researchers, we have provided the opportunity for one of our knowledge-holders to have the confidence to write further on game theory and how this could contribute to bringing the more-than-human world into RRI. We have kept the dialogue open to provide the space for engagement to take place, and there has been an opportunity for a non-academic voice to be heard.

The written piece also means that as researchers, we have to *Act*. In this case, the best way for us to showcase this written piece, was for us to turn it into this article as an example to our academic colleagues as to what can be achieved when working with non-academic knowledge-holders. For the project, the direction and the trajectory of the research has been influenced by the written piece produced by Min. This article is an unintended output which was not envisaged when the project commenced. Importantly for the project, the written piece shows that our knowledge-holders saw value in what we were trying to achieve with bringing the more-than-human world into RRI. The very fact it has been embraced makes the project worthwhile.

Whilst we have outlined how this written piece has been beneficial, there are criticisms aimed at the whole process of RRI. One of the critiques is around the lack of politics in RRI, and it is worthwhile reflecting on what this written piece means in this context.

The politics of RRI

RRI was supposed to ensure deliberative discussions around scientific and technological developments were opened up to a greater range of actors. This was to enable a larger number of voices to be heard. One of the criticisms levelled at RRI is that these dialogues are not occurring (**van Oudheusden, 2014**). Shanley et al. (**2022**) identified that what seems to be occurring in a European setting is that RRI is discussed by researchers in universities and by policymakers, however, citizens are omitted from conversations and therefore, RRI is not entering wider society. Discussions are not taking place as they should do.

The role of RRI when it was first conceived was to protect society from scientific developments that may not generate the best outcomes for individuals or society as a whole. However, unless policymakers, researchers and research funders start to consider the science-society relationship, and the purpose of innovation, RRI may instead be used to legitimise the economics of research and innovation (**de Saille, 2015**). Some scientists may wish to use RRI as a means to keeping politics out of scientific research to ensure new innovations occur. This will be problematic because if citizens are not given an opportunity to voice their opinions about new scientific and technological innovations at the development stage, there could be public resistance to these innovations when they emerge into society (**Hartley et al., 2017**).

This written piece by Min Burdett shows that these criticisms can be addressed. It is possible for RRI to be accepted by non-academic knowledge-holders, and willingly so. What is telling, is that Min writes in this piece that an RRI framework should ensure that deliberation occurs

between people from different backgrounds and from different academic disciplines like that which occurred at the one-day workshop. In addition, bringing the more-than-human into RRI frameworks such as AREA potentially opens up discussion to a much broader knowledge base than might otherwise be achieved. What this deliberation and discussion shows is that politics can be useful in RRI.

In this section, we have explained why the written piece about game theory matters, the implications it has for the AREA framework, and what it means for the politics of RRI. There is much to learn from the non-academic knowledge-holders (human and more-than-human) that participate in research projects. Because of the learning that has taken place in this RRI and more-than-human project, in the next section, we make recommendations to fellow researchers.

Recommendations

Attempting to include the more-than-human world in responsible research and innovation has been a journey full of discovery. The unexpected outcomes including this article reveal what is possible when RRI is fully considered as integral to the research process. In concluding, we make the following recommendations to researchers.

- Ensure all knowledge-holders (including those representing the more-than-human) who are impacted by your research have the opportunity to voice their opinion.
- Ensure that engagement is authentic and is acted upon. Non-academic knowledge-holders are unlikely to engage with activities that are tokenistic and do not influence research.
- Be open to how knowledge-holders can help shape research and demonstrate the impacts they have on research.
- Be open to how the more-than-human world can potentially help shape research.
- Invite response and criticism from knowledge-holders and be open to how this can inform research and shape methods or tools used.
- Prepare a plan to incorporate knowledge-holder input and to disseminate the findings or impact of that input.
- Consider how we include the names of our non-academic knowledge-holders in academic writing. If we are speaking of an academic's prose we would always use the last name. Should this approach be the same for non-academics?

What we have shown with this article, is that RRI does not have to be just a tick-box exercise. Creating a space for interdisciplinary and transdisciplinary conversations can be immensely rewarding especially when non-academic knowledge-holders are empowered to contribute their own ideas to projects. Including the more-than-human world in RRI is going to be needed more than ever going forward as we face troubling times with climate change and biodiversity loss. RRI provides a tool for enabling the coming together of communities around research. The more RRI can consider the more-than-human world and be envisaged as integral to research projects, the greater the chance of providing solutions to some of the world's most wicked problems which are acceptable to all and are inclusive of all.

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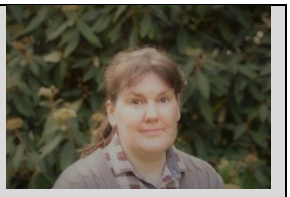

Min Burdett is a retired Management Consultant. Recruited by a consultancy firm's advert for a Decision Analyst, she used her Mathematics and Operational Research degrees to help clients better understand and implement their strategic decisions. In retirement she has returned to her rural upbringing, managing a woodland with her sister (including the small-scale production of biochar) and part-owning the family organic dairy farm with her brother.

Tom Bott is a soil scientist and molecular ecologist interested in soil nutrient cycling, specifically carbon, and the microbial communities that perform this service. Of interest to him are the changes microbial community structure and function in response to perturbation. His research focuses upon how the addition of biochar to soils might interact with soil ecosystem functions and therefore lead to changes to crop growth and soil biology.

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