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Informed adaptation: Ethical considerations for adaptation researchers and decision-makers

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ABSTRACT

Given the significant and irreversible impacts of climate change on communities and the environment, there is increasing focus on how to best support decision-makers to adapt to climate change. Generally, the research on this tends to focus on assessing how decision-makers navigate elements of risk and uncertainty in deciding to what extent they should adapt their practice if at all, however, scientific researchers also have a key role to play in supporting these adaptation decisions. Given the applied nature of adaptation research, we argue that an examination of the roles and responsibilities of researchers is critical to understanding the ethical aspects of professional research practice in the adaptation context. This includes identifying how researchers can best support adaptation, and exploring the responsibilities that researchers have, not only to decision-makers but also to the broader membership of the adaptation community. In this paper we examine the ethical responsibility of researchers in supporting decision-makers to adapt to climate change, using agricultural producers as a case-study and focal group. Specifically, in undertaking this examination of risk and responsibility in adaptation research and decision-making, we use the lens of professional ethics to outline how research might better contribute to informed adaptation. We argue that clarifying the distinction between the research and operational aspects of agricultural adaptation, and how the interface between the two is disclosed, is critical. We also describe and explore the ethical considerations of researchers associated with stakeholder engagement in relation to adaptation science, and identify the need for institutional innovation for more effective engagement. In doing so, we seek to demonstrate how ethical research practice can support greater alignment of science and public values in agricultural adaptation, thus increasing the likely success of decisions.

1. Introduction

Since the emergence of human-influenced trends in climate and the recognition of the current and future potential impacts of these shifts on agriculture, there has been an urgent call to address agricultural adaptation in a coherent way (e.g. Easterling et al., 2007; Meinke et al., 2009; Porter et al., 2014). This has been accompanied by increasing research effort dedicated to understanding how best to support adaptation decision-making among agricultural producers (Adger, 2003; NRC, 2009; Stokes and Howden, 2011). Agriculture is the most significant human land use throughout the world (FAO, 2002), and climate adaptation research in the agricultural sector has been examined from the soil, plant and animal level through to the farming systems level and the community and landscape levels (Adger et al., 2005; Hayman et al., 2012). Climate change is broadly recognised as being one of the defining factors affecting the future success of agriculture (e.g. Easterling et al., 2007) and this has important implications for both environmentally sound land management and the security of global food supplies (Rosenzweig and Parry, 1994; Easterling, 1996; Parry et al., 2004). In recognising the significant impact climate change is likely to have on agricultural production, a number of researchers have also identified that it is therefore likely the agricultural sector will need to make varying levels of adaptive change in order to remain viable under increasingly variable and changing climate conditions (Howden et al., 2007; O'Brien, 2011; Pelling, 2011; Rickards and Howden, 2012).

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Fig. 1. Spectrum of adaptation change.
Adapted from Rickards and Howden (2012).

In terms of determining the nature and extent of the impacts of climate change on the agricultural sector, there is a substantial degree of uncertainty at play arising from more than just divergent trajectories associated with anthropogenic greenhouse gas emissions (Meyer, 2012; Vermeulen et al., 2013; Waters et al., 2014). While we have witnessed advances in our scientific understanding of the potential impacts of climate change over time, there remain key climate systems like the El Nino-Southern Oscillation (ENSO) system, the inter-tropical convergence zone, the sub-tropical convergence zone, the Western Pacific warm pool, the southern annular mode and others that remain poorly represented in global climate models (Grose et al., 2014; IPCC, 2014a), and with relatively minor progress in resolving overall climate projection uncertainty for key developing country agricultural regions between the Coupled Model Intercomparison Project phase 3 (CMIP3) and phase 5 (CIMP5) models (Ramirez-Villegas et al., 2013). There is also substantial uncertainty from the choice and application of different climate downscaling methods (Hewitson et al., 2014) and application models (Piontek et al., 2013). This means that while making adaptation recommendations and decisions with the best science and knowledge available at the time, the uncertainties and knowledge gaps that exist should be acknowledged early in stakeholder discussions (Hewitson et al., 2014). This environment of uncertainty applies to both biophysical and socio-economic researchers working on climate impacts and adaptation, and to the agricultural producers who they work with, who are or may be affected by climate change.

Our interest in ethical practice therefore lies at the interface between adaptation researchers, the uncertain information they deal with, and those who apply this (and other) information through the decisions they make about adapting their agricultural production systems and businesses. While a focus on ethics in the climate change literature is not new, for the most part discussions of climate ethics have tended to adopt a broader and much higher-level focus on issues such as global equity, justice and the role of societal systems (Jamieson, 1992; Gardiner, 2004; Adger et al., 2006, 2009; Broome, 2008; Brown, 2013). For example, the question, '*what is humanity's ethical responsibility to adapt to climate change?*' has often been addressed in terms of emissions reductions in the climate ethics literature (Jamieson, 1996; Garvey, 2008; Brown et al., 2009; Gardiner, 2011; Harris, 2011; Schroeder et al., 2012). In response, a number of claims have been made to justify action on ethical grounds such as the need to reduce harm to humans and natural ecosystems and to increase equitable social outcomes, because it is considered a core responsibility of nation states in a global economy, and to ensure a positive legacy to future generations. While these are significant and important issues that demand broad attention, such high level discussions of climate ethics have tended not to focus on the nature of the direct interactions that take place between individuals or small groups. Although recent analysis by Hewitson et al. (2014) has examined the ethical responsibilities of researchers with respect to their methodological choices in climate downscaling, and the potential consequences of these choices, the nature of risk and responsibility at the interface of the research and operational aspects of adaptation requires further examination. For this reason, we seek to address explicitly the ethical issues that arise for researchers and practitioners in the agricultural adaptation context by posing the following question: '*What is our ethical responsibility as researchers in supporting others to adapt to climate change?*' We regard the role of ethics in structuring, implementing and delivering agricultural adaptation research as broadly relevant to all fields of adaptation research. However, we have chosen to use agricultural adaptation as an illustrative context within which to explore these issues in adaptation research and practice because of the more mature literature and practice when compared to many other sectors.

The need to undertake an ethical examination of adaptation research and practice emerges as a result of the variable, and in some cases conflicting, research recommendations about how agricultural producers could adapt their businesses being reported in the science literature. These recommendations broadly range from suggesting that no adaptation action should be taken by agricultural producers (Asseng and Pannell, 2013) through to suggesting that complete transformation of agricultural production is needed (Hoffmann, 2011). Like Hewitson et al. (2014), we are concerned that the variability of these recommendations in the science literature has the potential to increase the level of risk to decision-makers seeking to make an informed choice about how best to adapt their businesses. We argue that making informed adaptation decisions applies not only to being informed about the science itself and the related uncertainties surrounding the science, but also to being transparent and accountable about the choices of what science is being undertaken and how it is funded, and how adaptation research is communicated with those making adaptation decisions. This requires clarifying the distinction and interface between the research and operational aspects of agricultural adaptation. In doing so, we also seek to demonstrate how ethical research practice can support greater alignment of science values with public values in agricultural adaptation (Meyer, 2011).

2. Defining change in agricultural adaptation

In this section, we outline what we mean by adaptation in the agricultural context. Adaptation is defined by the IPCC (2014b) as "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate harm or exploit beneficial opportunities". Adaptation necessarily requires a response to managing the emergent risks, threats and opportunities posed by climate changes interacting with other, uncertain changes. In relation to agriculture and food security, there is a growing literature that suggests that incremental changes alone to existing systems may not be sufficient (Vermeulen et al., 2013). One way of conceptualising the nature of these adaptive changes is to consider the scales at which change may take place (Rickards and Howden, 2012). Fig. 1 illustrates three scales of adaptive change beyond the 'business as usual' position, where it is anticipated there might also be increasing costs, complexity and risks involved as we move up these scales.[1]

[1] For the purposes of this discussion, we have included a situation where no change is made. Although the decision not to act is not generally considered within the adaptation research literature or alternatively considered as a form of maladaptation (Barnett and O'Neill, 2010), we include it here in order to recognise the full range of adaptation options that decision-makers might consider as part of their decision-making process.

These changes range from incremental adaptation (e.g. change in crop varieties) through to systemic change (e.g. change from cropping to a mixed crop-livestock system) and finally, transformational adaptation (e.g. adopting a fundamentally different land use or the relocation of production activities). While Rickards and Howden (2012) note that, in reality, the distinction between each of these scales of activity can become blurred due to their heuristic and subjective nature and by the duration, extent and timing of the activities taking place, it may also be instructive to think about these scales of activity as representing a range of possible adaptation options available to decision-makers depending on their particular circumstances and motivations. In this context, we seek to understand the impact and relevance of researchers' contributions and how research findings can be used both ethically and effectively to help agricultural producers understand and navigate the *full range of relevant options* that may be available to them; in effect, we are interested in the role of researchers as 'honest brokers' of this adaptation knowledge (*sensu* Pielke, 2007).

It is also recognised the focus of climate adaptation research is about addressing transitions. This has been reflected in a shift from a sole focus on understanding and projecting the biophysical basis of climate change towards being more inclusive of social, economic, cultural, policy and institutional research about adaptation and mitigation (i.e. the transitions required to move from problem identification through to solution identification and implementation) (e.g. Cornell et al., 2013; Howden et al., 2013; Lebel, 2013). In order to move from impacts to understanding what it takes to adapt successfully and support people making decisions, the science has also needed to undergo transition. The risk of delivering science that does not meet these needs is a reduction in adaptation gains, and this has been widely documented. For example, Moser and Dilling (2011) refer to this as the need to close the science-action gap through better communication, education and engagement practices. Similarly, Sarewitz and Pielke (2007) highlight the problem as a growing gap between the supply of and demand for the research that is being undertaken versus that which is most needed. This is perhaps reflected in the proportionally fewer studies in the literature that report on adaptation actions and their impact (Berrang-Ford et al., 2011). Howden et al. (2013) also document the mismatch between the science and adaptation frontiers which effectively means there is a gap between the science being undertaken and the needs of those actually adapting. This gap could also reflect a growing tension between the metrics of science outputs and the direct and indirect impacts of research on the lives and decisions of end-users (which in some cases, are confounded by other factors or simply not measured). For researchers working in the applied context, these are very real challenges (Boardman and Ponomariov, 2007).

Thus, while biophysical climate research has been critical in fostering our understanding of the issues facing the agricultural sector, there arguably should now be a move beyond problem identification phase into solution identification and implementation supported by mechanisms for evaluating the effectiveness of these solutions. Understanding how science can make a difference in this way reflects the need to better understand the public good outcomes of adaptation research (Bozeman and Sarewitz, 2011; Meyer, 2011). This means demonstrating how adaptation research supports decision-makers in the context of the complexities they are operating within and in accord with broadly-held societal values (i.e. environmental, economic, institutional, social etc.). It also highlights the need to refocus our attention on the goals of adaptation research, and as researchers, to reflect quite explicitly on whether our efforts are delivering the public good benefits that are required of our (mostly) publically funded research. This is relevant because the public good values of science are often balanced against professionally-valued science outputs such as publications, awards, recognition within the science community, and the ability to secure ongoing research funding (Panaretos and Malesios, 2009). While these activities are critical to developing scientific careers and furthering scientific research, they are not always aligned with promotion of the public good values that drive the research itself (Guston, 2000; Shanley and López, 2009). Hence, there are calls for claims about the social benefits of adaptation research to be demonstrated (Sarewitz and Pielke, 2007; Meyer, 2011). This is particularly the case where those claims have the capacity to affect the livelihoods of agricultural producers and society more broadly.[2]

3. At the ethical interface of risk and responsibility

The interface of the research and operational aspects of adaptation research brings the ethical nature of our practice as adaptation researchers and our interactions with end-users into focus. We regard the core ethical dimensions of our practice as adaptation researchers (and/or practitioners) as revolving around how we conceptualise and manage risk and responsibility in those interactions.

The study of risk has a long history and it is recognised as "one of the major conceptual categories with which we describe our attempts to deal with an unpredictable future" (Hansson, 2008, p. 423). Broadly however, risk can be understood as being comprised of two components: the probability of an occurrence taking place and the consequences associated with that occurrence (Fischhoff et al., 1984; Holton, 2004). Both elements are critical at the interface of climate adaptation research and decision-making (Hewitson et al., 2014). Despite this, an approach that has dominated our thinking for close to a century identifies probability as the key defining aspect (Knight, 1921). While this is a highly deterministic approach to risk in that it relies on calculated probabilities to determine the likelihood or scale of risk present in a range of options, according to O'Brien (2011, p. 2), it is not unlike the way adaptation responses "often seem to be constrained by the projections of climate models and integrated assessment models, as if the future has already been decided and the challenge is for humans to adapt". Thus while the use of probabilities has provided one model for conceptualising risk, which has been taken up in a wide range of decision contexts, one of the main critiques of this approach is that it often fails to adequately take into account the element of exposure (i.e. the material consequences of making a particular decision) (Holton, 2004). These consequences may be positive or negative, anticipated or unanticipated but a critically important part of decision-making is about understanding, as best as possible, the consequences of a given decision. This means that while we can build part of the picture with our research models and predictions, there remain elements of decision-making that must be based on making a judgement about what constitutes an acceptable or unacceptable level of risk from agricultural decision-makers' own perspectives. This question of what constitutes an acceptable level of risk for decision-makers represents the point at which ethical judgement intersects explicitly with how we respond to scientific uncertainty (Brown, 2013).

We argue this intersection is instructive in terms of considering the distinct roles and responsibilities of adaptation researchers and decision-makers (Vogel et al., 2007). It also emphasises the very different relationship a researcher and a decision-maker have to the adaptation decision itself – particularly in terms of who should

[2] It is also possible that the end-users of adaptation research may be a government client interested in policy development. For the purposes of this paper, we are limiting our focus to the individuals and groups that are engaged directly in agricultural production and would be making decisions about adapting these businesses.

determine the level of risk and who should accept responsibility for the level of risk associated with a particular adaptation decision. Brown et al. (2009) argue that determining what constitutes an acceptable level of risk is almost impossible in the absence of any criteria of acceptability and this highlights a critical difference between scientific research and ethical decision-making (see also Hansson, 2003). How a decision-maker responds to the results of scientific research and determines the 'right' course of action is very much driven by their subjective values and beliefs. Science "cannot, by itself, generate prescriptive guidance" (Brown et al., 2009, p. 26). Determining the 'right thing to do' is simply not the domain of scientific research, it is a decision based on ethics and values. The point here is that such a decision can be informed by science, but the science itself does not and cannot fully resolve the complexities of the decision process which tend to include the range of personal, social, political, economic and institutional factors that affect such processes (Meyer, 2011; Jacobs, 2014).

Brown (2013) points out that the tension between science and ethics is evident in the way the proof standards of science become problematic when we attempt to apply them to practical situations. In particular, this becomes most pronounced when we consider who should bear the burden of proof when it comes to potential harms resulting from a decision to act (or not). For example, every decision carries consequences but it is difficult to see how scientific research is capable of determining just how much risk should be carried by individual decision-makers, or what responsibility would be carried by researchers assigning that risk to decision-makers. This reflects a combination of scientific and ethical decision-making that can only be achieved if researchers are working together with decision-makers, and can be responsive to and inclusive of a range of particularities of context, motivations and capacities (Jacobs, 2014). This means working beyond the mechanical application of a probabilistic risk-based framework to ensure that researchers do not (either intentionally or unintentionally) impose unnecessary risks on decision-makers, and that decision-makers are informed about the risks to the greatest extent practicable so that they can determine if they are willing and able to accept those risks. It is for these reasons we argue it is necessary that researchers and decision-makers must have a clear understanding of their respective roles as either describing, resolving, imposing or accepting risk, and that the framing of these roles cannot be predicted in terms of probability frameworks or modelling. Rather, the ethical nature of these responsibilities must be determined based on recognising a clear difference between:

- intentional and unintentional risk exposure in adaptation: in this case, researchers have significant responsibility in terms of ensuring their research recommendations provide the full range of appropriate options to decision-makers and do not unintentionally close out relevant options as this may increase the risk exposure, which includes risk created by conflicts of interest such as advocating one's own research, for example; and
- voluntary risk taking: risks imposed on a decision-maker who willingly accepts them (i.e. is well informed), and risks imposed on a decision-maker who does not accept them (i.e. paternalistic or coercive behaviour or as a result of not being well informed) (based on Hansson, 2012).

Thus, if we view one of the core responsibilities of adaptation researchers as supporting effective adaptation decision-making, we might anticipate this would be achieved through provision of decision support resources (i.e. information, knowledge, support tools) and the unbiased and comprehensive communication of the options, and the benefits and risks associated with them. Not to do this may place researchers in the position of imposing higher levels of risk on decision-makers (whether intentionally or unintentionally). This emphasises the need for the information being exchanged between researchers and decision-makers to be useful, relevant and actionable, and for the communication process to be appropriate for the relevant end-user(s) (Cash and Buizer, 2005; Meinke et al., 2006; Buizer et al., 2010). Importantly however, this can only happen if researchers have a good understanding of what decision-makers need and decision-makers know what researchers have to offer; in other words, establishing an effective knowledge market.

4. Ethical considerations related to stakeholder engagement and knowledge exchange for agricultural adaptation

We consider the ethical issues around *increased risk exposure*, and *voluntary or imposed risk*, are most visible at the interface of knowledge exchange between researchers and decision-makers. This requires that, as researchers, we are willing to acknowledge the role of our own expertise, beliefs and values in the exchange of research findings but also how this can implicitly or explicitly inform recommendations made to end-users.

Risk can arise in part from the different ways researchers define and respond to adaptation. While we suggest there are various scales of adaptive change (Fig. 1), not all researchers agree with this, instead choosing to focus exclusively on one aspect of adaptation (e.g. examining technological innovation but ignoring institutional change). The risk here is that researchers may become advocates for their own research without full transparency that their recommendations represent only select information (aligned with their own knowledge or expertise) and not necessarily the broader array of adaptation options that are available, thus transferring un-identified risk to the end-user (Pielke, 2007). Such behaviour on the part of the researcher effectively diminishes the choices available to decision-makers and to some extent, assumes a partial role in the decision-making process, which we argue is not the responsibility or function of the researcher. Rather, recommendations that are appropriate to decision-makers must be aligned with their specific contextual circumstances, needs, beliefs and values, not those of the researcher (O'Brien and Wolf, 2010).

Concerns have also been raised about the values placed by some researchers on particular adaptation options and how they are communicated. Some researchers recommend that no adaptive change is appropriate. For example, Asseng and Pannell (2013, p. 176) in their observations on adapting dryland agriculture in Australia have suggested that because climate projections are inherently uncertain, "there are benefits from delaying decision-making about adaptations until after changes have occurred and the uncertainty can be resolved". Here, the proposition is that scientific information is too unreliable to support any action on the part of decision-makers, even via incremental change. This contrasts with surveys indicating a majority of farmers are adapting to the climate changes they have already observed (e.g. ABS, 2009; Schwarz et al., 2012) and studies indicating climate changes are already affecting crop yields in many regions (e.g. Porter et al., 2014 for a meta-analysis). On transformational adaptation, there are also a range of views. For example, O'Brien (2011, p.4) observes, "transformation is increasingly presented by scientists and activists as the 'solution' to environmental change and social sustainability". However, others are communicating transformational adaptation as an option of last resort, only to be applied once all other limits of adaptation have been reached or exhausted; a matter for the distant future (e.g. Dow et al., 2013). This contrasts with evidence that some agricultural decision-makers are already making transformational adaptation decisions (e.g. Park et al., 2012). By placing negative values on actual and quite serious adaptation actions in the present, researchers

effectively bias objective recommendations to decision-makers by placing value-laden labels on available adaptation options.

While this brief analysis highlights some disagreement in the science literature about what the best course of adaptation action might be; our concern is that this variability in approaching, scoping, defining and providing advice could be restricting adaptation progress, partially through a blurring of the boundaries between the research and operational aspects of adaptation (Howden et al., 2013; Hewitson et al., 2014). This could mean privileging increasing accuracy of prediction at the expense of impact. Sarewitz and Pielke (2000, 2007) have similarly argued while there is scientific value in the knowledge that has helped us to better understand climate change, increasing levels of certainty may not be what is most required to support decision-making. By analogy they suggest, "it's as if the National Institutes of Health focused its research on making better projections of when people will die, rather than increasing practical ways to increase health and life expectancy" (Pielke and Sarewitz, 2002–03, p. 29). Additionally, much of the research focuses on the problem (i.e. climate impacts) rather than the adaptation solutions (Berrang-Ford et al., 2011). However, this is not only about investing in science that will be most useful at the operational level, rather the ethical nature of the issue being explored lies with how effectively this information can be shared with, and thus used by, decision-makers. As we have identified, there is clear divergence in how recommendations for practice are being identified in the science literature. We think the risks inherent in this conflicting advice can be illustrated by how these issues are managed in the medical domain.

4.1. Translating research to operational practice: Insights from the medical profession

The use of a medical analogy is relevant for three reasons. First, advice provided in the medical and adaptation domains has a direct impact on lives (or livelihoods) (Pfaff et al., 1999). Second, it is recognised that ongoing investment in basic medical research continues to contribute to important medical developments. However, there are significant challenges with translating this research into improved health care outcomes for end-users (Dougherty and Conway, 2008). Third, looking at the established practice of how frontline medical practitioners (i.e. here we refer to family physicians and general practitioners as opposed to medical researchers) work with their patients to provide diagnosis, advice or develop co-management plans provides useful insights for how advice or recommendations to the end-users of adaptation research might also be managed in a way that continues to take risk and uncertainty into account but also contributes to a practice that is both more effective and ethical.

Let us consider a patient presenting to their family physician. It is not unrealistic to expect this patient would receive a diagnosis aligned with their set of symptoms, and that should another general practitioner be consulted by the patient (e.g. in the absence of their family physician), this diagnosis would be much the same. That is to say, we expect the diagnosis to be effectively invariant of which general practitioner is consulted. In fact, it would be deemed highly unsatisfactory (and potentially life threatening), if the patient was to visit a number of different general practitioners and receive vastly different diagnoses or treatment plans at each consultation as a result of each general practitioner's disciplinary or values bias, their sponsorship by a pharmaceutical company (i.e. inducements to prescribe particular products), or their unwillingness to refer patients requiring specialised care. In fact, we would regard these failures as unethical as it would suggest the core motivation of the practitioner was not aligned with delivering the best quality health care to the patient.

However, in adaptation research there seems to be a risk that moving between experts for advice will generate a different diagnosis of the problem and the solution required. For example, the different general circulation model (GCM) chosen, downscaling technique applied, or emissions scenario adopted can potentially result in different future climate representations and consequently different impacts and adaptation scenarios (Hewitson et al., 2014). Similarly, choice of methods such as only GCM-based results can focus the user towards long-term impacts even though they may need advice specifically relevant to their immediate or short-term needs (Howden et al., 2013). Furthermore, the adaptation approaches recommended to decision-makers may also differ depending on whether the expert being consulted has a preference for a particular disciplinary approach (e.g. economics, social science etc.) or particular climate models, methods or predictive techniques (Pfaff et al., 1999). Where such divergence exists, we need to ask how we might ensure the best quality outcomes for end-users of adaptation research.

A useful way to approach these issues is to think about how the research and operational aspects of medical research are managed in practice. Dougherty and Conway (2008) outline three translation activities in the healthcare domain as comprising basic science and its initial translation into clinical research (transition 1 or T1), a shift to understanding treatment effectiveness in the clinical setting (T2), and finally, developing systems to support the delivery of evidence-based treatment to patients (T3). We consider these translations can be usefully applied to the adaptation domain (Fig. 2).

By conceptualising these transitions from basic research about the nature of climate impacts (T1) through to determining the best adaptation options (T2) and finally, the implementation of adaptation solutions (T3), we can draw out key differences in the roles and responsibilities of researchers at each stage, and also how risk to end-users can be managed. In our example of the family physician, advice is most likely being provided at the T3 stage as it is assumed to be based on rigorously tested and broadly accepted information. While this does not entirely preclude the existence of risk and uncertainty in providing advice to patients (i.e. each individual is different and every consultation draws on the general practitioner's best assessment of the presenting issues at the time), it is clear that the preceding translations support rigorous consideration and management of risk in this clinical setting with the patient. However, if an adaptation researcher operating at T1 began offering recommendations on the best adaptation options to end-users, there is a clear and unacceptable risk being created for the end-users. This is not unlike Price's (1965) discussion of the locus of responsibility in relation to science which runs from scientists through to professionals (e.g. engineers and physicians), and then onto administrators and politicians (see also Guston, 2000). While it may be argued that adaptation research is still developing and adaptation options are still undergoing refinement, it also seems the problem around the variability of how research is communicated but also which research is communicated (in the form of advice or recommendations) is related to the privileged position of the researcher in influencing decision-makers.

We recognise the above example of a patient consulting their family physician offers a highly simplistic view of frontline health care. It downplays the existence of a divergence of views among general practitioners on patient care, which are undoubtedly influenced by a range of individual opinions and interests. However, what is of interest to us here is that within the medical domain, there are established mechanisms and processes in place for managing these differences of opinion and how they might impact on patient care. For example, there are established means of obtaining second opinions and processes for resolving any differences in the advice being provided. Patients are also regarded

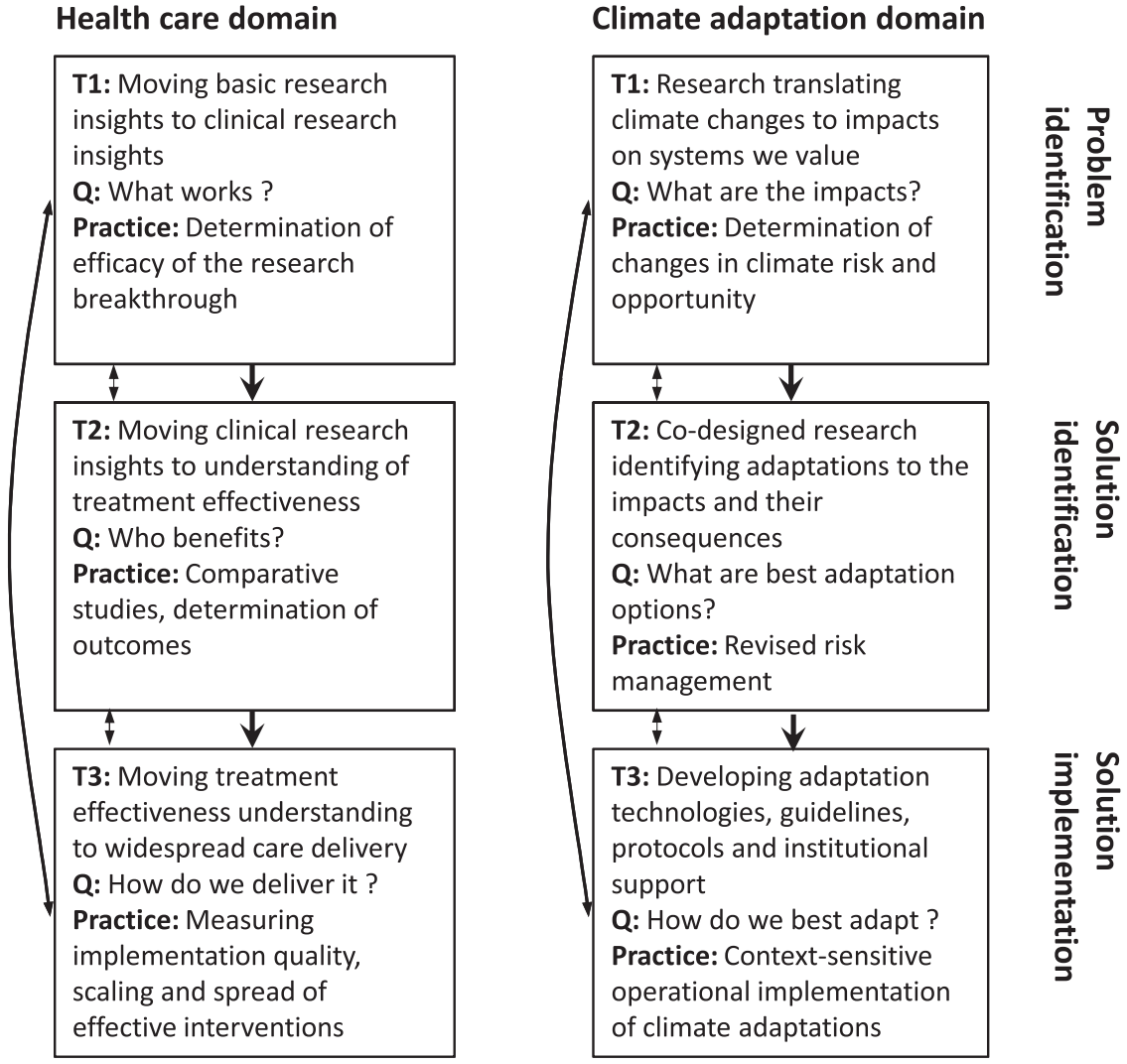

Fig. 2. Transforming research to operational practice in two domains.
Adapted from Dougherty and Conway (2008), Howden et al. (2013), and Garfin (2014).

as being in the position to make the final decision over their health care after they have had the opportunity to consider such diverse advice (i.e. the final decision is never made by the practitioner and even in cases where patients are unable to make such decisions on their own behalf, there are legal mechanisms in place to seek family permissions and so on). General practitioners are required to constantly update their clinical knowledge to ensure they provide current advice (González-González et al., 2007), which means they are in a position to not only advise patients about how they might secure a second opinion or what the patient might need to consider in their circumstances but also to provide referral where a specialist medical practitioner is better equipped to provide patient care and advice. Similarly, the marketing of pharmaceuticals to health care professionals is monitored within a system of compliance and accountability in order to maintain the highest ethical standards in patient care and reduce the risks associated with financial inducements (Grace and Cohen, 2013). These behaviours are governed by a recognised system of professional medical ethics developed primarily to protect the interests of patients.[3]

[3] For example, the American Medical Association adopted a set of ethical principles in 1847 (these have since been revised on a number of occasions). The principles are not considered laws but rather standards of conduct which define ethical behaviour among physicians (American Medical Association, 1995–2014).

The purpose of the medical analogy is to highlight the distinction between the research and operational aspects (and the associated risks and responsibilities) within a system. Our issue in the adaptation domain is not so much the degree of engagement or that there are joint activities underway between researchers and decision-makers, but rather that in some cases researchers may be (intentionally or unintentionally) representing their research findings, which are not yet broadly accepted by the wider adaptation community, as uncontroversial inputs into the operational decision-making of end-users. This has the potential to increase the risk exposure of decision-makers. Alternatively, researchers may, during project development with end-users, be representing their research as suitable for operational decision-making but the key outputs (e.g. reports) carry disclaimers as to the suitability for this use. In other arenas, this would raise questions of false or misleading claims being made (ACCC, 2014). What remains problematic from the perspective of appropriate risk management is that this influence could translate to adaptation decisions made on the basis of *who* is providing the expert advice rather than the personal and *contextual circumstances* of the end-user themselves. Thus, the mechanisms for communicating information between the research and operational aspects of adaptation also require closer examination. In this regard, we argue adaptation researchers

have a responsibility to act as 'honest brokers' (*sensu* Pielke, 2007).

4.2. Transforming research to operational aspects: organisational system challenges

Traditionally, the communication of science to decision-makers was based on the knowledge-deficit model, a uni-directional process whereby scientists as 'authoritative experts' and the producers of knowledge were most accountable for making that knowledge available to decision-makers (Bensaude-Vincent, 2009). However, under such an approach the risk of bias increases. According to Pielke (2007), the idea of researchers as honest brokers goes beyond this model, and focuses on researchers providing factual, empirically-based advice that does not reflect their own personal preferences. This behaviour, when integrated with an effective engagement process (e.g. the co-production of knowledge; see Jasanoff, 1990), could allow scientists to be seen as credible, legitimate and salient sources of information, become trusted advisors to decision-makers, and improve the likelihood that scientific information is integrated into decision-making processes (Cash and Buizer, 2005; Granderson, 2014; Vaughan and Dessai, 2014). Engaging in this way requires adaptation researchers to move beyond traditional methods of communication and engagement, and seek opportunities for two-way exchanges of information (van Kerkhoff and Lebel, 2006; Cornell et al., 2013; Cvitanovic et al., 2014a). Examples include having decision-makers take part in scientific advisory boards (T3 activities) or enacting participatory research processes (T2 activities), whereby decision-makers actively take part in research projects from the outset (e.g. Crimp et al., 2010; Cvitanovic et al., 2013).

More recently, scientists have come under increasing societal and political pressures to engage more actively with decision-makers. For example, Lubchecno (1998) called for scientists in all disciplines to engage in faster and more effective sharing of knowledge with decision-makers. Similarly, a recent survey of 1521 Australian scientists found that 89% agreed that as a scientist they have a personal responsibility to communicate and engage directly with society, including decision-makers (Searle, 2013). These changes have increased institutional pressure on scientists, with many research organisations now formally recognising engagement of decision-makers as a core responsibility of scientific roles (Searle, 2013). Hewitson et al. (2014) further suggest that scientists have an ethical obligation to provide information on uncertainty and consequences of different methodological choices to end-users so as to inform their decisions. While at face value it appears reasonable to assert that science, and therefore scientists, have an ethical obligation to inform, in a balanced way, decision-making processes, the underpinning mechanisms via which scientists can be supported in doing this or held accountable are far less certain (Lamberts, 2013). Serious structural impediments and institutional barriers often prevent this from occurring successfully (see Shanley and López, 2009; Cvitanovic et al., 2015).

For example, the need for greater accountability in academia has led governments, research authorities and university administrators to assess research performance using single indices that allow comparisons and ranking (Panaretos and Malesios, 2009). While these measures capture output performance, they fail to capture the impact of research more broadly (Adler and Harzing, 2009). We argue that research institutions have an ethical obligation to remove these structural impediments through innovative thinking and a commitment to end-user engagement (Lebel et al., 2006). Internationally, there are attempts to address this issue (e.g. Owens, 2013) but with no clear direction to date, the existing system and metrics will continue to dominate the research being conducted which biases, and in some cases privileges narrowly focused, single disciplinary and quantitative studies. In contrast, it has long been acknowledged that effective adaptation research uses a mix of methods, including longitudinal approaches and works across a spectrum of science activity from problem identification (T1) to solution implementation (T3) (e.g. Wollenweber et al., 2005; Nastasi et al., 2007; Uiterkamp and Vlek, 2007). This allows building an evidence base through broader accountability, spread of research, and evaluation. It also supports the transition of basic research through to solution identification and implementation in the adaptation domain.

In response, agricultural research institutions (and others) are already seeking to implement strategies to overcome barriers such as these through novel approaches to knowledge exchange. There is a growing body of literature providing empirical support for using knowledge brokers or boundary organisations to improve the uptake of research by decision-makers (Guston, 2001; Lavis et al., 2003; Buizer et al., 2010; Clark et al., 2011; Crona and Parker, 2012). While the role and function of knowledge brokers and boundary organisations are conceptualised and operationalised differently in various sectors and settings, the key feature of these roles is to facilitate knowledge exchange between and among various stakeholders, including researchers, practitioners, and policy makers (Michaels, 2009). Jacobs (2014, p. 2) has documented innovative approaches to the use of "science translators" emerging in both the public and private sectors, including consultants and major agribusiness corporations, as a way of tailoring information and assisting stakeholders navigate the complexities of adaptation science. This is just one example of how institutions might not only alleviate pressure on their scientists but also improve engagement with decision-makers (Cvitanovic et al., 2014b). However, given these organisational system challenges, we believe there may be value in examining a role for professional ethics among adaptation researchers and knowledge brokers.

5. A role for professional ethics in adaptation research

The value of thinking about professional ethics in this context is twofold. First, it shines a light on the motivations and behaviours of those undertaking adaptation research and engaging with stakeholders to ensure they are not increasing the risk exposure of decision-makers. Second, it highlights that ethical practice in the profession is not the same as error-free practice. Behaving ethically does not remove risk and uncertainty from adaptation research and practice but it does make a certain kind of risk much more explicit, and this allows us to manage it more effectively. For example, medical ethics do not stop people getting sick but, for the most part, they do protect patients from physician behaviours that are not aligned with their ongoing well-being.

Professional ethics is best understood as the guiding ethical principles or framework adhered to by a group of professionals, such as medical doctors, lawyers or engineers in the service of human needs. Questions about the goals of science and whether scientists and researchers can be considered a professional group in this regard have been subject to a long and robust debate (e.g. Bush, 1945; Polanyi, 1962; Rip, 1994; Toulmin, 1964; Weinberg, 1970, 1972; Wilson, 1991). According to Airaksinen (2012), if the overarching goal of science is simply to advance the state of scientific knowledge, while this may have some benefit to humanity, it tends to remain logically independent of any direct commitment to advancing the public good. This approach represents what we might associate with pure or basic research where the greater good is defined as the advancement of knowledge for its own sake. In this understanding of science,

Table 1
Formulating a response to ethical challenges in adaptation research and practice.

Ethical issue	Proposed responses
Conflicts of interest (e.g. disciplinary bias, personal values and opinions about adaptation options, researchers acting as advocates for their own research, career metrics etc.) which can create risk for end-users and decision-makers	• Raise awareness among adaptation researchers of the range of factors influencing their own behaviours and motivations in increasing the risk profile of end-users and decision-makers. • Although this is not the sole responsibility of scientists, individual behaviour will inform the development of acceptable professional standards in the adaptation community.
Provision of conflicting advice to end-users and decision-makers (i.e. managing divergence of opinion)	• Adapt the research transitions model (T1–T3) that has been successfully applied in the medical research sector to develop a broadly accepted system for what kinds of research can and should be communicated to end-users, when and how. • Effective communication might be best managed by functions such as specialised science translators or boundary organisations but the transitions model would provide a framework for conceptualising risk and responsibility for the adaptation profession and support professional practice among researchers.
Lack of alignment in science and public values	• Develop a set of ethical adaptation principles to guide adaptation research and practice that are broadly accepted by the adaptation community and aimed at promoting the social benefits of adaptation research. • This may imply a revision of some aspects of the science rewards system that currently work against science being delivered for end-user impact.
Lack of formal mechanisms to support ethical adaptation research and practice	• Develop formalised processes to support researchers to promote the ethical use of adaptation research. • For example, processes from the medical sector such as mechanisms to acquire second opinions or referrals to specialists might be equally useful in the adaptation sector. This would require a commitment across the broad adaptation profession to establish networks around maximising adaptation outcomes to end-users and decision-makers.

we would be unlikely to consider scientists as professionals in the same way we understand the contribution of other professions (e.g. doctors, teachers etc.) which are operating in the direct service of human needs. However, if the overarching aims of scientific research are to contribute to supporting human needs and social goals then we can legitimately conceptualise scientists as a profession. This is particularly the case where the express purpose of such research is to directly improve or change the lives or conditions of end-users or the broader environment.

This idea that scientists represent a profession with distinct ethical responsibilities is not new (Rotblat, 1995). To some extent, there is already evidence of this among adaptation researchers in the formation of groups such as the American Society of Adaptation Professionals (ASAP), which have formed around the shared goals and responsibilities of an identified profession dedicated to preparing "for the impacts of climate change and mak[ing] their communities, regions, states, and the country more resilient to those changes" (ASAP, 2014). In the case of agricultural adaptation research, the science often addresses understanding and improving the viability of our agricultural production systems under changing climate conditions and identifying the best ways to do this. However, it is not yet clear if we have the appropriate checks and balances in place to support full disclosure in the communication of research findings to decision-makers (i.e. where both strengths and limitations of research are transparent). For these reasons, we believe there is value in the adaptation research community being more explicit about potential conflicts of interest in professional practice.

A core part of our ethical responsibility as researchers is to address the foreseeable consequences of our research. This includes acknowledging that risk can be created in the way we communicate our findings to end-users and other stakeholders, and as we have also seen, the potential conflicts of interest (e.g. disciplinary bias, researchers acting as advocates for their own research, or researchers motivated by career metrics over value to decision-makers) that can create additional risk in the recommendation of particular adaptation options. Where there is potential for research to impact directly upon the livelihoods of decision-makers, and where there is potential for harm to be created as a result of adopting a particular research recommendation, a conflict of interest exists, and this is the case "not only when an interest has an *actual impact*. . .but also when a *substantial risk* for an adverse impact occurs" (Crystal, 1998, p. 85 quoted in McMunigal, 2001, p. 65). By explicitly addressing these issues, we believe ethical research practice can support greater alignment of science values with public values in the agricultural adaptation sector, and ultimately, more successful decisions. Table 1 summarises the nature of these emerging ethical challenges for adaptation researchers.

In reaching this point, we have sought to demonstrate the importance of the distinction between the research and operational aspects of adaptation research and practice and why it is so important to highlight the distinct roles and responsibilities of researchers and decision-makers operating in the adaptation context. Ideally in applied research, solutions to adaptation problems might be developed by incorporating a range of views, be appropriate to decision-makers' needs and largely independent of which researcher is involved in the process.[4] Such collaborative or participatory processes tend to share power, responsibility and knowledge. Where solutions or recommendations have been generated by researchers without meeting these basic criteria, this must be clearly communicated so decision-makers are aware of any conflicts of interest that may be embedded in adaptation options. However, it is equally important that those undertaking the research and engaging with end-users can agree to a set of ethical principles that support their own practice and uphold the standards of the profession.

6. Conclusion

In this paper, ethics has provided a way of conceptualising risk at the interface between research practice and how it is communicated and applied. By highlighting the variability in

[4] See the extensive discussion in the literature on both the value and associated transaction costs associated with engaging stakeholders in science discussions (see Jasanoff, 2003; Jacobs et al., 2005, 2010; Cash et al., 2006; Eden, 2011; Kirchoff et al., 2013).

how adaptation research and associated adaptation options are currently being presented in the science literature, we have revealed how the communication of adaptation research may inadvertently be increasing risk exposure among agricultural decision-makers. Such increased risk exposure can be exacerbated by conflicts of interest arising from narrowed or biased presentation of research findings that intentionally or unintentionally close out the options that are available to decision-makers, the challenge of balancing the metrics of science outputs with research impact, and advocating one's own research when it may not be appropriate in specific circumstances. We also argued that considering the roles and responsibilities of adaptation researchers through the lens of professional ethics may support the development of an ethically defensible practice of adaptation research and practice. Importantly, it must be recognised that ethical practice is not, in and of itself, error-free practice nor does it guarantee a certain outcome. Behaving in an ethical way does not inherently remove risk from adaptation research practice or decision making; rather it allows us to more explicitly manage certain types of risk related to the motivations and behaviours of those operating in this domain.

The idea of a professional ethics for adaptation researchers demands significantly more discussion than we have been able to provide here, however, we believe it may be a useful approach for thinking about the nature of conflicts of interest as they arise in agricultural adaptation research and how they can be managed. This is particularly the case where there is potential to increase the risk exposure of decision-makers. In this regard, we have sought to describe and explore a number of key ethical considerations for researchers associated with stakeholder engagement in relation to adaptation science, and we have further identified the need for institutional innovation to support more effective engagement. Clarifying how risk and responsibility interact at the interface of the research and operational aspects of agricultural adaptation also allows us to examine the existence of intentional and unintentional risk exposure, and voluntary and involuntary risk taking in adaptation decision-making, and how we, as researchers, may contribute to or shape these outcomes. While we in no way suggest that a consensus in all views in agricultural adaptation research must be reached, there does need to be broader discussion about how we communicate research findings and further reflection on ethical practice in this context. In reflecting critically on how we individually and collectively contribute to progressing the overall goals of agricultural adaptation research, we believe ethical research practice will also support greater alignment of science and public values in agricultural adaptation and more successful decision-making in this domain.

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