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Mitigation of climate change. Risk and uncertainty research gaps in the specification of mitigation actions

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ABSTRACT

In this perspective paper, we are concerned with the general problem of how to increase the probability of achieving the expected outcomes of climate change mitigation actions. Climate change mitigation actions prevent, limit, reduce, delay or slow the rate of environmental changes produced by greenhouse gas emissions. A mitigation action can fail to achieve its intended outcome or create an adverse outcome elsewhere, which means uncertainty about mitigation outcomes or risk. Thus, mitigation risk can be defined by the deviation from a given mitigation goal and the associated uncertainties. We observe a lack of take-up of crucial concepts associated with risk in the climate change mitigation literature. Next, the concepts of risk, risk perception, risk acceptance and agents' concerns are sometimes used interchangeably. As discussed in this paper, this has resulted in a lack of research about, for example, critical causes of mitigation failure. This situation means that some crucial knowledge gaps remain unaddressed or little researched. In this paper, we strive to identify those research gaps that need to be addressed in managing mitigation actions. Based on literature on risk, clarifications and distinctions regarding the potential meaning, scope, roles and implications among key concepts, such as risk knowledge, mitigation risk, uncertainty, agents' concerns, risk perception and risk acceptance are given. A key distinction is that the central concept of concerns is associated with agents' objectives, interests, visions, needs, preferences, norms, criteria or values and is different from risk perception. Following this, the gaps this perspective paper discusses are identified and justified by the analysis of how specialised literature in mitigation of climate change reflects aspects linked to the risk concepts. The discussed gaps entail the identification and operationalisation of agents' concerns, the lack of knowledge about the influence of risk perception and risk acceptance on the weighting of agents' concerns, and the impacts of the disparity in power relations among agents involved in mitigation.

1. Introduction

Despite increased pressure to undertake policies and actions at all governance levels (transnational, national and local), climate change mitigation has failed so far to provide the expected responses. Climate change mitigation prevents, limits, reduces, delays or slows the rate of environmental changes produced by greenhouse gas (GHG) emissions. The actions already taken to reduce global GHG emissions have not yet generated major outcomes across the entire globe. Based on the nationally determined contributions (commitments) before the United Nations Climate Change Conference COP26, projections of emissions for the year 2030 will make 'it likely that warming will exceed 1.5°C during the 21st century' (IPCC, 2022).

Within the next 50 years, global net-zero emissions are required, to keep global warming 'well below' 2℃. Net-zero emissions will be achieved when humanity's GHG emissions into the atmosphere are balanced by their removal. However, in so far as 'GHG emissions remain above net zero, the planet will continue warming'. Accordingly, it is argued that a drastic reduction in emissions and a significant increase in carbon uptake from the atmosphere need to be achieved (IPCC, 2021, 2022).

Many technological and institutional mitigation options are considered. They include demand reductions through reduced activity and efficiency, rapid decarbonisation of the electricity sector and low-carbon electrification of transport, buildings and industry. Decarbonisation options are also required in energy supply and use, food systems and

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land use. Another option considered is the disruption of existing developmental trends, e.g., the ongoing production and consumption patterns that have been major drivers of GHG emissions (IPCC, 2021). It has been shown that climate change is the result of decades of unsustainable production and consumption patterns. The political-economic institutions and governance arrangements that commit unalterably to resource-intensive development patterns are also a cause of climate change (IPCC, 2021). Without changes in these development patterns, the mitigation options described above may not be able to meet the mitigation goals. Very high economic and social costs will also be expected if the development patterns do not change (IPCC, 2022). The radical shift of development trends highly depends on many global and national actors and involves the crucial aspect of lifestyle changes. Further, all this is envisioned to be more feasible if performed in terms of equity. It is argued that mitigation actions accepted as equitable, e.g., in a fair distribution of costs or risks, are likely to be implemented with greater willingness than those enforced under other conditions (IPCC, 2022).

Public choices, as the specification of mitigation actions may be, are usually supported by risk analysis (National Research Council, 1996). It is desirable that risk knowledge be provided by risk analysis. Such knowledge is to be exchanged or shared between and among the public (Society for Risk Analysis, 2018). Next, a deliberative process can take place to determine a course of action (National Research Council, 1996; Renn, 2009). The deliberative process is seen as a means to weight or balance public concerns raised by the proposed activity under scrutiny (Aven, 2019). Given the failures to achieve the urgent mitigation goals and the nature of their challenging options, the consideration of risk in mitigation results essential. The IPCC has provided some conceptualisation regarding risk about mitigation actions. The guiding document is *The concept of risk in the IPCC Sixth Assessment Report: a summary of cross-Working Group discussions. Guidance for IPCC authors* (Reisinger et al., 2020). This guiding document acknowledges that a mitigation action can fail to achieve its intended outcome or create an adverse outcome elsewhere, which means uncertainty about mitigation outcomes or mitigation risk. *The guidance note for lead authors of the IPCC Fifth Assessment Report on consistent treatment of uncertainties* (Mastrandrea et al., 2010) summarises alternative ways of representing uncertainty. Despite these developments, we note a pervading confusion, as well as a lack of understanding and, in turn, take-up of crucial concepts about mitigation risk in climate change mitigation literature. Consequently, crucial aspects of mitigation risk knowledge have not been addressed. For example, currently, there is a lack of conclusive evidence about critical causes of mitigation failure.

Considering these issues, this paper's objective is to identify those crucial knowledge gaps that remain little researched due to the lack of consideration of fundamental concepts associated with risk and uncertainty in climate change mitigation. To meet this goal, first, we will analyse some concepts from existing risk analysis frameworks. Then, the identified gaps will be further justified by the analysis of how specialised literature reflects aspects linked to the gaps. The respective literature search is described in the Appendix to this paper.

The definition of mitigation action based on Stern et al. (2022) further determines the scope of this research. Mitigation actions prevent, limit, reduce, delay or slow the rate of environmental change produced by greenhouse gas emissions. This means that adaptation and related aspects are beyond the scope of this paper. This paper is also focused on mitigation risk, namely uncertainty about mitigation outcomes. Yet, it contributes to the ultimate end of climate change mitigation, which is to reduce climate change risk globally. The challenge is stabilising the climate at acceptable risk levels (Nielsen et al., 2020). Note also that here, climate change risk is distinguished from mitigation risk. Climate change risk is understood as the risk that arises from the impacts associated with climate change (e.g., O'Neill et al., 2022; UNDRR, 2022). The paper also emphasises mitigation through changes in agents' behaviour, which appears to offer more advantages than other forms of mitigation actions (Moreno et al., 2023).

The need for increased consideration of risk in mitigation is also highlighted in the IPCC (2022) mitigation report. There is a call for 'Accelerating mitigation (…) [which] will require the integration of broadened assessment frameworks and tools (…)'; these include 'Approaches to risk assessment and resilience, (…) [to be] complemented by frameworks for probing the challenges in implementing mitigation (…).'

The remainder of this perspective paper is structured as follows. The next section describes some useful concepts from frameworks for risk governance and risk analysis. In a subsequent section, the pursued research gaps are identified and described, based on the analysis of how specialised literature in mitigation of climate change reflects aspects linked to the risk concepts. The conclusions of the paper are presented in the final section.

2. Concepts to be considered in the specification of mitigation actions

In its very primitive characterisation, decision-making is a process of gathering information and knowledge, evaluating alternatives and making a final choice or determining a course of action. In the process, the advantages and disadvantages of each alternative considered are weighted and the extent to which an alternative meets certain criteria is assessed (e.g., benefits and costs) (Simon, 1947; Keeney, 1982; Lipshitz and Strauss, 1997). When many agents are involved, as in the case of specifying (identifying and describing) mitigation actions, making such choices is more complicated. Ideally, in public decisions, knowledge is made understandable and accessible to the agents involved. Next, a deliberative process should also take place to address the significant concerns raised by the proposed activity under public consideration (e.g., National Research Council, 1996). The deliberative process implies a collective reflection on the course of action to be taken and is informed by different assessments including risk analysis (Renn, 2009). It has significant relevance, given that concerns are usually disparate among agents (National Research Council, 1996; Renn, 2009). In the context of climate change and based on Renn (2009) and Aven (2019), we see the deliberative process as a means to weight or balance all these highly disparate concerns. A central activity in balancing concerns is communication, and this includes the exchange or sharing of risk-related data, information and knowledge between and among different agents, namely *risk communication* (Society for Risk Analysis, 2018). Thus, based on this description, in the context of climate change mitigation, we consider two major steps in specifying mitigation actions. We shall say that *knowledge production* and the *weighting* or *balancing of agents' concerns* are at the core of the specification of mitigation actions.

The knowledge to be produced is not only about climate-related events or quantities but also about climate change risk and mitigation risk (e.g., Kunreuther et al., 2014). *Co-production of knowledge* is a more appropriate label, since knowledge to be provided by risk analysts, experts and scientists is required to meet the *agents*' knowledge needs. Next, knowledge, based on the agents' experience can often be used to question and modify analysts' conclusions (National Research Council, 1996). For Stern et al. (2022), agents could be an individual, social movement or public or private organisation that undertakes initiatives to mitigate environmental damage. We include, as agents, people who need to know about climate change, those who can make the desired changes and influence decision-makers and other agents, as suggested by Moser and Dilling (2007). It follows that agents' response is that produced by the mitigation actions' implementation (Stern et al., 2022).

First, we clarify that the concept of *knowledge* associated with climate change might not refer, in many instances, to objective knowledge, as conventionally understood. Future and unobserved climate-related events or quantities (e.g., earth surface temperatures or agents' response) cannot be known with certainty or assume a value before they occur (Aven, 2020). Based on Cardenas et al. (2023), we say that, unlike

objective knowledge, climate change knowledge can only be justified by using direct evidence that becomes available, indirect evidence from other observed quantities, supported by modelling projections, and expert judgement. Aven (2019) has suggested that, ideally, such knowledge should not be value-laden.

Here, the central concept of *concerns* is associated with agents' objectives, interests, visions, needs, preferences, norms, criteria or values. A definition for this concept still needs to be agreed upon and distinguished from other concepts such as risk or risk perception, as discussed below. From this definition, it follows that the balancing or weighting of agents' concerns is a broader task than the analysis of benefits and costs conventionally used in determining a course of action (National Research Council, 1996; Renn, 2009; Aven, 2019). Unlike traditional approaches to decision-making (e.g., Simon, 1947), in endorsing the proposed definition for agents' concerns, aspects other than people's values need to be considered. Another consequence is that the balancing of agents' concerns is not only about determining risk acceptance criteria, for assessing different alternatives. Examples of fundamental agents' concerns could be the majority of the 17 sustainable development goals (SDGs). Clearly, the SDGs reveal a mixture of diverse agents' objectives, interests, visions, needs, preferences, norms, criteria or values.

Regarding the concept of *mitigation risk*, Aven (2020) has suggested that the risk concept has two main components: i) the consequences of activities and ii) the associated uncertainties. For example, consider an intervention, e.g., a mitigation action such as a decarbonisation programme in a country. This intervention can lead to some consequences in the future. However, the consequences are unknown during an assessment and, therefore, subject to uncertainty. The consequences may be related to deviations from the decarbonisation objective. It followsthat risk can be defined by the deviation from the objective and the associated uncertainties. Uncertainty is, therefore, a central concept linked to the concept of risk (Aven, 2020). According to the Society for Risk Analysis (2018), *uncertainty* is lack of or incomplete knowledge about a quantity (property of a system) or event. Using this definition implies that uncertainty can be solely linked to quantities or events (Cardenas et al., 2023). According to the concept described, risk is, ideally, non-value-laden and distinct from the notion of risk perception (Aven, 2020).

Additional distinctions should be given. *Risk perception* is a person's subjective judgement or appraisal of risk (Society for Risk Analysis, 2018), while *Risk acceptance* is an attitude expressing that the risk is judged acceptable by a particular individual or group (Society for Risk Analysis, 2018).

3. Risk and uncertainty knowledge gaps in the specification of mitigation actions

To meet the objective of this paper, in the following, we will identify some opportunities to improve the specification of mitigation actions. The focus is on identifying knowledge gaps that originate from the lack of take-up of crucial concepts about risk in the specialised literature. After the joint description of the risk concepts in the previous section, here, we discuss them and analyse how specialised literature in mitigation of climate change, including the IPCC (2022) mitigation report, reflects or disregards the risk concepts. Following this, knowledge gaps are identified and discussed. We should note that the IPCC's document reported a substantial review of climate change mitigation literature that provides an important source of information to discuss in relation to the identification of gaps. The sources have been identified using the procedure described in the Appendix to this paper.

Knowledge gap 1 (KG1): The influence of risk perception and risk acceptance on the weighting of agents' concerns.

The IPCC (2022) report emphasises the radical shift of development trends as a mitigation option. This shift should result from multiple choices made by many agents in the global and national contexts. Such choices include socio-behavioural changes (IPCC, 2022). Moreno et al. (2023) have suggested that channelling mitigation through agents' behavioural changes has relatively more advantages than other types of mitigation actions. An influential factor in social-individual response is apparently risk perception (Kasperson et al., 1988). Renn (2009), (2011) has highlighted the role of risk perception in governing systems such as the climate system. Risk perception might be conditional on many individual and collective heuristics of information processing, cognitive-affective factors, the trust that agents have in government and knowledge sources, the cultural background, experience and context (Renn, 2009). In the setting of climate change, risk perception confounds many factors and, as a consequence, varies greatly among agents (e.g., van der Linden, 2015). Thus, an uninformed agent's perception is unlikely to match the knowledge provided by risk analysts, experts and scientists (Kunreuther et al., 2014).

It has been hypothesised many times that no matter how strong the climate knowledge provided by risk analysts, experts and scientists is, risk perception is what determines the ultimate response by agents (e.g., Moser and Dilling, 2007; Hulme, 2009; Malone, 2009; Renn, 2011). However, recent literature reports conflicting evidence about the actual impact of risk perception on agents' climate response (e.g., Steynor et al., 2021; Wang et al., 2021; Hurst Loo and Walker, 2023; Hochachka, 2024). Rather, a no-direct perception-response link with the mediation and moderation of many other factors and a strong dependency on the context analysed is shown. Some moderation factors considered as such in the specialised literature include communication and social norms. Yet, conflicting evidence of the disparity between public communication about climate change and the lack of behavioural change has also been observed in the general public (van der Linden, 2014; Vainio et al., 2017; Schneider, 2019; Berneiser et al., 2022; Ceyhan and Saribas, 2022; Hurlbert and Osazuwa-Peters, 2023; Palosaari et al., 2023). Likewise, van der Linden (2014) and Chan et al. (2022) raised doubts about the observance of social norms as an influencing predominant factor that affects action on climate change. What is more, disparate evidence also showed that even agents highly engaged in mitigation (engagement is a mediation factor) actions fail ultimately to respond (Roser-Renouf et al., 2014; van der Heijden, 2018; IPCC, 2022).

As seen, the dominant literature is focused on seeing risk perception as one central causal factor influencing climate change response. Such a focus is problematic, since conclusive evidence has not yet been provided about the actual significance of risk perception. The focus is also problematic because risk perception is often confounded with the concepts of risk, risk acceptance and agents' concerns (see e.g., Baiardi and Morana, 2020; Wang, Geng, Rodríguez-Casallas, 2021). A more analytical effort is required, and, accordingly, distinctions among the concepts of risk, risk perception, risk acceptance and agents' concerns are to be considered. In line with this, other causal mechanisms can be formulated that approximate more closely how decisions are made (e.g., Lipshitz and Strauss, 1997). Accordingly, we hypothesise that risk perception influences agents regarding how concerns are weighted. Another proposition is that risk acceptance, in the form of risk aversion or risk proneness, impacts how agents give weight to different concerns. From all the above, it follows that differences in risk perception and risk acceptance could also explain diversity in concerns among agents. The causality implied in these hypotheses is more consistent with the way decisions are made (e.g., Lipshitz and Strauss, 1997). Recall that, to determine a course of action, based on some knowledge, which can be strong or weak, eventually, agents weight their concerns and, in turn, would respond.

From the above, it can also be hypothesised that, if strong knowledge is actually used by agents, it will have an impact on limiting the effect of the issues of high disparity of risk perception, as suggested originally by Aven (2019), and, ultimately, agents' concerns can be better balanced. Disclosing uncertainty is also seen as ultimately influential in creating trust among agents (Aven, 2019; Lamb et al., 2020), a factor that influences risk perception (Renn, 2009). An increased response by agents

can also be hypothesised, in turn.

In the research of this proposed knowledge gap, we should take into consideration that, undeniably, the imbalance of agents' concerns (as defined here) together with limited knowledge have been the pervasive outputs in the endeavour of climate change mitigation. This situation has hampered or is likely to hamper the specification of mitigation actions and, ultimately, an increased mitigation response.

Risk acceptance is an important factor (Kunreuther et al., 2014) that would play a major role in specifying mitigation actions. Risk acceptance is an attitude expressing that the risk is judged acceptable by a particular individual or group (Society for Risk Analysis, 2018). de Sadeleer (2022), for example, has shed some light on the disparity and change of authorities' and states' views on addressing global environmental damage over recent decades. This author discussed how the precautionary principle was ultimately adopted in 1997. The principle states that if the consequences of an activity (e.g., ongoing drivers of global warming) are judged unacceptable and subject to uncertainties, then cautionary measures should be taken, or the activity should not be carried out (Aven, 2019). Although the concept emerged in the 1970s–80 s in Germany, only in 1987 gained international recognition at the International Conference on the Protection of the North Sea. The proclamation of the precautionary principle was made in the United Nations Framework Convention on Climate Change in 1992. During negotiations in Kyoto in 1997 the principle was finally adopted.

Based on a literature search described in the Appendix to this paper, there is a lack of sources using the distinctions about the concepts of risk given previously and the causal mechanism hypothesised. Some sources have mainly discussed rather than researched the issue in a fragmented way, considering only some of the risk concepts described in this paper (Gifford, 2011; Medvecky et al., 2014; Busby et al., 2015; Hagen and Pijawka, 2015; Xue et al., 2015; Nauges and Wheeler, 2017; Choon et al., 2019; Bradley et al., 2020; Chen, 2020; Munoz-Carrier et al., 2020; Zobeidi et al., 2020; Carton et al., 2023; Hübner et al., 2023; Lind et al., 2023; Oliveira Tavares, 2023). Meanwhile, others confound the different risk concepts when operationalising (abstracting and measuring) them (e.g., Baiardi and Morana, 2020; Wang et al., 2021).

Knowledge gap 2 (KG2): *The conceptualisation, operationalisation and assessment of agents' concerns*. We have suggested that two major steps should form the specification of mitigation actions, namely knowledge production and the weighting or balancing of *agents' concerns*. Unfortunately, a definition for the concept of agents' concerns is not provided by the literature on climate change; consequently, in some instances, agents' concerns are confounded, e.g., by aspects of risk, risk perception or risk acceptance.

When considering the aspects linked to the concept of concerns, namely agents' objectives, interests, visions, needs, preferences, norms, criteria or values, existing quantitative research specifically studying, e.g., the causes of climate inaction, falls short, since only some of the suggested aspects linked to the concept of agents' concerns are actually operationalised. We observe in the sources analysed that the way the aspects of agents' concerns are operationalised does not acknowledge that agents' concerns are different from risk, risk perception and risk acceptance (e.g., Busby et al., 2015; Steynor et al., 2021; Baiardi and Morana, 2020; Wang et al., 2021; Munguia et al., 2022; Pagliuca et al., 2022). The conceptualisation and operationalisation of agents' concerns deserve consideration in future climate inaction research.

We should also note that, often, when it comes to adopting or implementing mitigation actions, some mitigation actions raise among agents concerns that are different from or even opposite to those linked to the risk to be mitigated. While agents can acknowledge some climate change risks, they may also perceive the solutions, namely the mitigation actions, to be unpleasant or unpalatable (Renn, 2011; Campbell and Kay, 2014; Kunreuther et al., 2014; Kyselá et al., 2019; Ma et al., 2019; Perlaviciute and Squintani, 2023; Hochachka, 2024). Moser and Dilling (2007) envisioned that the indisputable concerns about equity and fairness might run into conflict when used in specifying some mitigation actions. For instance, some mitigation actions promoting clean energy use often prioritise environmental and economic outcomes at the expense of equity and social concerns (Penttinen, 2022). Likewise, Campbell and Kay (2014) pointed out the problem of agents perceiving the mitigation actions as unpleasant or unpalatable, resulting in failure to adopt and implement them. An example is that, in the United States and Canada, concerns about the economic costs of adopting mitigation actions and the influence of fossil fuel interests have limited the development of mitigation (Kuh and Leach, 2022).

Overall, in future research addressing KG1 and KG2, additional input can be provided by Weber and Johnson (2009), who distinguished between perceptions of risk, attitudes towards risk and loss aversion. Demski et al. (2015) also differentiated among public values, attitudes and acceptability; van der Linden (2017) established distinctions between risk perception and concerns; and Prati et al. (2018) and Kendal and Raymond (2019) analysed the shifting of agents' values, beliefs and concerns over time, suggesting the idea of short- and long-term concerns. Research about factors linked to public preference and willingness to pay for tackling climate change impacts (e.g., Chaikumbung, 2023) could also be input. We can also suggest that the measurement and prediction over time of agents' concerns are to be performed specifically for each context, as somewhat recommended by Huijbregts et al. (2022) in the setting of public values.

Knowledge gap 3 (KG3): *The influence of disparity in power relations among agents.* In discussing KG1, we identified some moderator factors linked to climate change response. These included communication and social norms. Other moderator factors are the capability of agents and power disparities. It could be expected that these moderator factors will be associated with how the burden and risks of mitigation are borne by agents. These factors are discussed here.

Highly capable governments are required to regulate important national agents; however, as cooperation progresses, at some point, governments become increasingly unable to commit to what agents are interested in (Keohane and Victor, 2011). Zengerling et al. (2022) provided evidence of the limited control and power some municipalities have over the high carbon emitters' sector in three large cities. Meanwhile, Kuh and Leach (2022) have shown the imbalance of both concerns and power relationships across the federal jurisdictions in Canada, which has resulted in a plurality of mitigation regimes, difficult to coordinate at the national level. Steg et al. (2022) concluded that institutional factors, including institutional, coordination, legal and administrative capacity, overall inhibit the implementation of many mitigation options.

Next, we can also note that there is a considerable number of loosely coupled agents attempting to mitigate climate change. Their loosely coupled condition is believed to be hampering effective climate response. Among the causes that produce loosely coupled systems are the imbalance of concerns, disparity in power relationships among agents, and risk and uncertainty about the returns agents will obtain. Cooperation on highly complicated issues with the involvement of a large number of other agents is often seen as risky (Keohane and Victor, 2011). An example is the modest regional cooperation, in the form of emissions trading, cross-border trade, technology exchanges and joint research projects in renewable energy, in several countries in the Asia-Pacific countries, which has been described by Zahar (2022).

Sparenborg (2022) has also suggested that the difficulty in predicting how impacts will be distributed, makes it possible for disparities in risk acceptance to be pervasive; in turn, the balance of concerns is compromised.

In the IPCC (2022) report on mitigation, the power relationships feature has received some attention. The IPCC recognises that the interaction between politics, economics and power relationships is central to explaining why broad commitments do not always translate into urgent action (IPCC, 2022). The report also highlights, in some instances, that some factors associated with power are obstacles to mitigation. This IPCC report also suggests investigating '[h]ow the

historic position of states within international power relations conditions their ability to respond to climate change'. As focused work on KG3, we refer here to some sources. Renn (2009) states that public decisions can also be seen as power transactions. They can attempt to redistribute risk and also power. Failure in the decision-making process includes a perpetual inequitable distribution of risks (National Research Council, 1996; Renn, 2009). Adekola (2020) highlights that power might be overused by any agent, including risk analysts, experts, communicators and private organisations, in the communication of risk. Cook et al., (2017), Lamb et al. (2020) and Mendy et al. (2024), for example, describe discourses pervading current debates on climate action as possibly originating from misinformation. There are discourses that, although accepting the existence of climate change, strive to justify inaction. Meanwhile, Sparenborg (2022) has advanced hypotheses between power and justice. We expect that specific work breaking down the influences of the high level of disparity in power relations among agents will shed some more light on, for example, its relation to climate change inaction. Addressing this research gap can also pursue the connection between agents' concerns and power alongside the role of justice, as might have been suggested, to an extent, by Sparenborg (2022).

A further question can be raised on how to surmount the disparity of power relationships to achieve the mitigation goals. In this perspective paper, we have acknowledged that the persistent imbalance of agents' concerns and, to a lesser extent, the limited climate knowledge have hampered climate change mitigation. We also suggested that the causes can be traced back to the disparity and evolution of risk acceptance and the moderation of communication. Here, based on the risk and mitigation concepts analysed, we can only suggest the continued use of deliberation during the specification of mitigation actions. The specification of mitigation actions balancing, at least, fundamental concerns (as the SDGs may be) –will contribute to easing the balancing and to an extent limit the issues generated by the unbalance of power relationships. We should also note that the deliberation is also implemented to build confidence and trustworthiness, through the clarification of facts, reduction of uncertainties, involvement of relevant agents and accountability (Aven and Renn, 2018; de Gooyert and de Coninck, 2024). The general expectation is that deliberation will help to build trust (Aven, 2019) to, among others, counterbalance disparities in power relations.

4. Conclusions

Here, we strived to identify knowledge gaps that need to be addressed in managing risk of mitigation actions. We believe that a conventional review would fail to identify these gaps, without a previous clarification and analysis of crucial concepts about risk. Clarifications and distinctions regarding the potential meaning, scope, roles and implications among key concepts, such as risk knowledge, uncertainty, agents' concerns, risk perception and risk acceptance, were given.

The knowledge gaps entail the influence of risk perception and risk acceptance on the weighting of concerns by agents, the identification and measurement of agents' concerns, and increased investigation of the impacts of the disparity in power relations among agents. Specialised literature has not addressed exhaustively these knowledge gaps in mitigation.

The proposed perspective paper is focused on climate change mitigation risk linked to changes in agents' behaviour, which appears to offer more advantages than other forms of mitigation actions. New research efforts should distinguish the different agents involved, e.g., policymakers and the public who should respond by adopting new behaviours.

The lack of take-up of the concepts associated with risks by specialised literature in mitigation risk is demonstrated, based on a systematic search of literature described in the Appendix to this paper. However, the identification of the causes of such lack of take-up deserves further consideration in new research undertakings. Another very relevant and potential knowledge gap is the potential linkages between mitigation of and adaptation to climate change in terms of risk and uncertainty. A future paper can discuss this issue.

Insofar as research bridging the identified gaps is conducted, the factors leading to agents' response failure can be more accurately established, and then more successful mitigation actions could be identified which could lead to a greater chance that mitigation goals are achieved.

CRediT authorship contribution statement

Ibsen Chivata Cardenas: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. Idea for the article, literature search and data analysis, draft and critical revision of the work was made by the author.

Declaration of Competing Interest

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Data Availability

No data was used for the research described in the article.

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Appendix- Additional literature search description

A systematic search was conducted using the Scopus bibliographic database. More specifically, the Scopus query used was TITLE-ABS-KEY ("climate change" AND mitigation) AND risk AND perception AND concern AND acceptance). This search produced 260 publications within the period 2007–2024, on 10th June 2024. After text mining the abstract, introduction and conclusions of each of these 260 sources, eventually, 29 publications provided somewhat useful input within the focus of the perspective paper which limits to research analysing agents' response. These 29 sources were examined thoroughly. Additional relevant sources were considered, based on cited sources of the 29 identified references.

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