Climate Risk Management: Framings, Evolution and Relevance:

In prep for the pre-scoping meeting, Nairobi, 5-7 April, 2017

EARLY DRAFT

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Introduction

This paper was prepared as input to an international scientific meeting on Climate Risk Management, taking place in Nairobi from 6-8 April 2017, intended to inform the scoping of the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC). The paper attempts to understand, from reviews of literature, how climate risk is understood, communicated and how it is being applied as a means of climate change adaptation or risk reduction.

The original audience for IPCC was primarily the UN and governments dealing with climate change in international negotiations, as well as the associated scientific and policy-making communities. The scientific evidence provided by the FAR led, in part, to the formation of the United Nations Framework Convention on Climate Change (UNFCCC) (IPCC, n.d.). By now, the IPCC has an audience way beyond the international climate negotiations, including in the highly vulnerable contexts where scientific information and capacity are often sparser, yet the risks of climate change often more pronounced.

Now, questions being asked of the assessment reports that *inter alia* include: Are risks of climate change mostly due to changes in extremes, changes in average climate, or both? Can science identify thresholds beyond which climate change is dangerous? What communities are most vulnerable to the impacts of climate change? These and other questions were explained in the Frequently Asked Questions for the AR5 WGII, which also brought into focus the concept of Climate Risk Management (CRM), which supports early decision-making in climate adaptation, looking at risks across timescales.

The IPCC is now embarking on its Sixth Assessment cycle, which will focus on, *inter alia*, understanding the magnitude and pattern of climate risks, now and into the future, partly depending on choices made on mitigation, adaptation, and sustainable development.

Effective communication of assessment findings means that the process must be framed in a way as to meet the requirements of receptivity (as explained in Tversky and Kahaneman's (1992) concept of “perception is reference dependent”). For the AR6 the IPCC has a wide range of options for how to frame the assessment of climate risk and climate risk management. This paper explores that inquiry, which will be further pursued at the meeting in Nairobi.

The Development of Risk Framing in IPCC Assessment Reports

The Intergovernmental Panel on Climate Change (IPCC) was set up by the World Meteorological Organisation (WMO) and the United Nations Environmental Programme (UNEP) in 1988 to prepare reports on climate change and formulate realistic response strategies (IPCC, n.d.). The IPCC’s task was outlined in the UN General Assembly Resolution 43/53 of 6 December 1988 to prepare a comprehensive review of the state of knowledge of the science of climate change, as well as its social and economic impacts and then to prepare possible response strategies (IPCC, n.d.). This report, published in 1990, was the first IPCC Assessment Report (FAR). The early questions being answered in the FAR were whether climate change was happening and if so, was it affecting or likely to affect socio-economic systems and the environment.

The FAR predominantly had an impacts assessment frame (Tegart et al., 1990). Although it used the term "risk", there were few references to it and mostly in the context of supporting ecosystems being "at risk" without contextualizing further. Potential climate changes mentioned related to drought frequency, without giving indications of trends. Adaptations and mitigation responses that we are now familiar with, called "Implementation measures". GHG emissions mitigation was not a concern of the report.

The IPCC's Second Assessment Report (SAR) then introduced the concept of adaptation to the projected impacts in its WGII (Watson et al., 1996). The term "risk" was used within particular context of the health risks of climate change, but these were speculative mostly, drawing linkages from environmental changes to health outcomes (Watson et al., 1996). IPCC assessments remained in an impacts framing, but now drawing more strongly on an adaptation component.

A fuller concept of risk in IPCC assessment reports emerged in the Third Assesment Report (TAR), and especially in the Working Group II (WGII) report on Impacts, Adaptation and Vulnerability (IPCC, 2001). The Reasons for Concern "Burning Embers" diagram first appeared, communicating the increasing likelihood of systems being affected by global warming. The term "vulnerability" was introduced as a component of susceptibility to climate change impacts. At this stage of IPCC assessment reporting, the term risk was used both as a noun and verb but without further embellishment as to some of its inherent characteristics or attributes. Examples include "an increased risk of damage to a number of crops", or "an increased risk of forest fire" (IPCC, 2001). The word impact was also used interchangeably with risk.

In the Fourth Assessment Report (AR4), the concept of risk combined the attributes of magnitude of the impact with the probability of occurrence, which "captures uncertainty in the underlying processes of climate change, exposure, sensitivity and adaptation" (Carter et al., 2007). Further, Chapter 2 of WGII Impacts, Adaptation and Vulnerability introduced the concept of Climate Risk Management (Carter et al., 2007). Two forms of climate risk management were identified as "mitigation of climate change through abatement of GHG emissions and GHG sequestration, and the adaptation to the consequences of a changing climate" (Carter et al., 2007). The adaptation component specifically concerned agriculture, but climate risk management was not developed further from there. Reducing vulnerability to increased presence of climatic hazards through disaster risk reduction (DRR) was identified as a means of disaster management (Yohe et al., 2007).

AR4 represented a significant departure in terms of the treatment of framing and outlines of the assessment reports, particularly concerning WGII (Burkett et al., 2014). Directly from that report, there is an increasing focus on "1) adaptation limits and transformation in societal and natural systems; 2) synergies between multiple variables and factors that affect sustainable development; 3) risk management; and (4) institutional, social, cultural, and value-related issues".

An even bigger step was made in the Fifth Assessment Report (AR5), which started off with a Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). This report, prepared in response to the increasing calls for information on the changes in extremes in a changing climate, and on ways to better manage those risks as part of climate change adaptation. This report, and the AR5 at large, noted that climate change was primarily a challenge of "risk management" (IPCC, 2012a), framed as decision-making under uncertainty. SREX successfully bridged evidence from disaster risk reduction and climate change adaptation, and established climate risk management (CRM) as a framing concept (IPCC, 2012b), also towards the AR5 at large, and beyond extreme events. The AR5 thus also adopted updated definitions of risk and vulnerability, noting that risk results from the interactions of hazards (including the changing climate), as well as exposure and vulnerability (see next section).

According to the chair's vision paper for the scoping of the AR6, the next assessment will build on this risk framing, but focusing even more strongly on *solutions*. *"In the AR5, the climate change impacts and responses were essentially viewed through a risk- based framing approach, developed mostly by WGII. This approached conceptualized the risks arising from the overlapping of climate hazards, exposure and vulnerability, leading to impacts that provide feedback to socioeconomic processes and the climate system. The AR5 assessed the potential for reducing the risks through both adaptation and mitigation. The concept of risk in the AR5 was derived from a rich set of literatures on risk, risk perception and risk management, and these are entirely compatible with a solution-based framework and indeed derive from similar motivations.* ***The integration of the risk framework with the solutions- focused, problem-solving frameworks should be the overarching framing of the AR6****."*

Details of the risk framing: Hazard, vulnerability, exposure

Since SREX and AR5, the IPCC views risk as the interaction "between hazard (triggered by an event or trend related to climate change), vulnerability (susceptibility to harm) and exposure (people, assets or ecosystems at risk)." (Figure 1). Climate change alters the likelihood of diverse outcomes through different pathways, including adaptation and mitigation, but also more general socio-economic development, which is itself affected by the impacts of climate change (IPCC, 2014a).

This framing represents an integration of risk management at the short timescales, of weather events occurring in days and weeks, with long-term trends and changes. The right choice of metrics, such as frequency of particular events, allows policy and decision-makers to conceptualize and respond to climate change across timescales (Coughlan de Perez et al., 2014). The framing can indeed integrate climate change outcomes from a range of probabilities -- not only those with high probabilities of occurrence but also those with low probabilities and large consequences. In addition, this risk framing can be applied across timescales, and also across spatial scales. It is commonly used at the very local level, and can also be applied to sectors and regions.

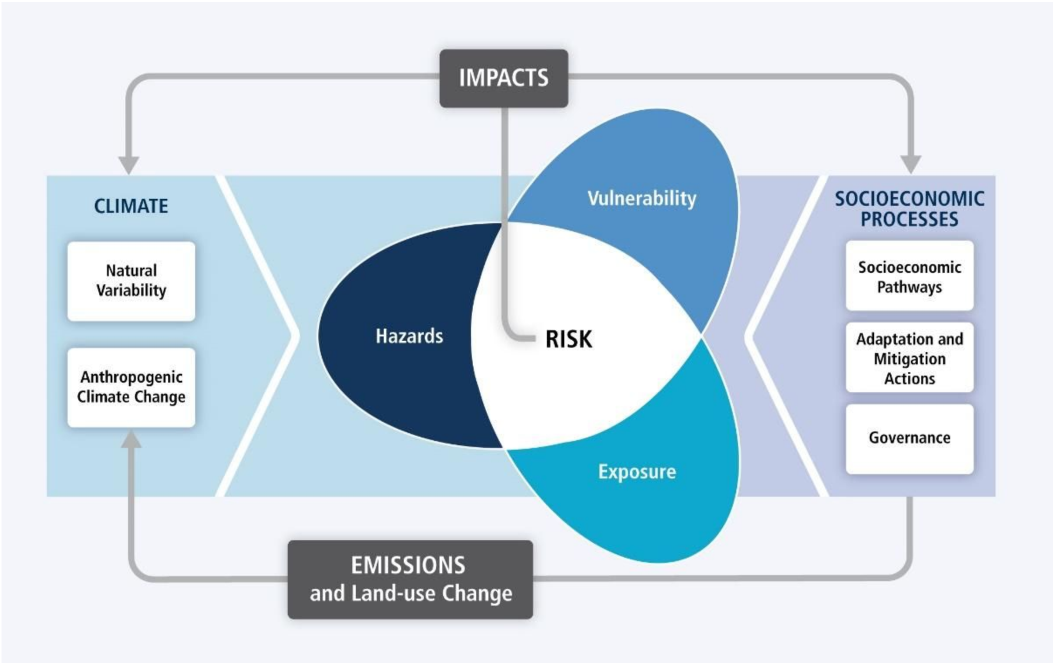

Figure 1 The IPCC hazards and risk framework (Source: IPCC AR5, 2014: Fig 19-1 (Burkett et al., 2014).

Challenges with this framing include how to organize the understanding of the mechanisms and interlinkages between these components and how to measure them. A particular challenge for an IPCC assessment of literature is that the literature on vulnerability and exposure (and ways to manage them through enhanced risk management) is way beyond the specific climate change context. In addition, it is highly context-specific, so it is often difficult to aggregate across regions or sectors, partly for lack of one simple metric for the different dimensions of risk.

In the context of the AR5, the IPCC attempted to at least provide a synthesis of key risks across regions and timescales (see Assessment Box SPM.2 | Regional Key Risks of the SPM for WGII of AR5, IPCC, 2014b). Different risk levels were considered along with different timeframes for different adaptation rates. For one, this overview makes it clear that risk levels are not equivalent across regions (IPCC, 2014b).

An additional perspective on risk: Reasons for Concern and the Burning Embers Diagram (BED)

The BED is a component of the "reasons for concern" framework of the IPCC (IPCC, 2012a). The BED is an aggregation of the impacts of climate change into 5 "Reasons for Concern" (RFC), relating increases in global temperature to increases in intensity of impact. Regional temperature increases have observably had an impact on local physical and biological systems. The frequency of other climate risks – floods and droughts, could not be strongly identified with this warming, however. The BED was first published in the TAR, as a means of communication, then left out of AR4 on the basis of strong objections from some states and then included again in the synthesis report of AR5. Earlier criticisms included that it was subjective, but by acknowledging that the AR5 synthesis report was not communicating data but concepts of change, it could be re-included. The problem with the BED is that it does not represent the different thresholds of different systems – not all ecosystems are the same. Shaw (2015) writes that the 2°C maximum increase as the limit of safety is an arbitrary value that is primarily a product of political expediency. A strong critique of the 2°C limit is provided by Knutti et al., (2016), who question the validity of setting this limit.

O'Neill et al., (2017) consider that there is no single quantitative risk metric for each RFC because each aggregates over a number of different risks. Some thresholds are posited, however, with transitions from moderate to high risks occurring ~1.1 – 1.6 °C, which is the transition between "Undetectable/Moderate" to "High/Very High" risks, which includes a range of climate aspects such as increased rainfall intensity and heatwave frequency. Increased risks combine when CO_2 concentrations reach 560 ppm and global temperatures reach 2.5 °C above the long-term baseline.

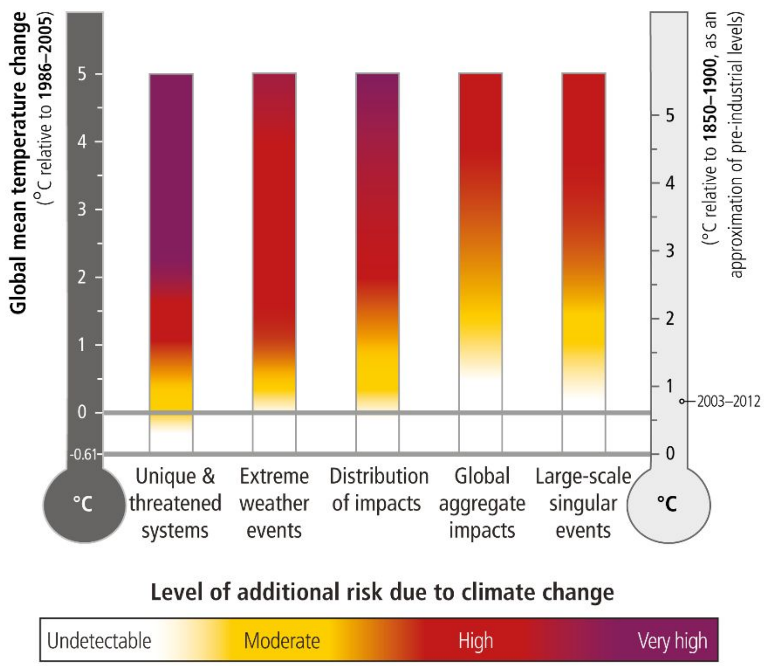

Figure 2 The IPCC "Reasons for Concern" or "Burning Embers" diagram (Source: (Oppenheimer et al., 2014)

Ongoing research needs the RFCs to include greater systematic evaluation of key risks, an improved quantitative understanding of differential impacts across a variety of possible climate futures and for a larger number of key risks in different sectors (O'Neill et al., 2017). More work on vulnerability, the socio-economic dimensions of such transitions (discussed above), alternative societal developmental pathways and their related vulnerabilities is required, as is the transparency of the process (O'Neill et al., 2017).

Alternative framings for a climate assessment

As IPCC assessment reporting has developed in scope and content, so have the approaches for assessing vulnerability to climate change evolved. This gives rise to the need to effectively communicate a complex, technical and highly detailed message in a way that focuses people's attention and conveys the details and relevance of the subject matter. Framing the content and messages that places them in a field of meaning, allows people to organize, interpret and present ideas. The IPCC therefore needs to frame its assessment reports in a way that best conveys the key issues at hand, for specialists and non-specialists alike. This section investigates some of those framing alternatives.

Alternative: Integrated Assessment Modelling

Integrated assessment modelling combines information from a variety of social, economic and environmental sectors and uses this to help decision-makers understand difficult and complex problems. Integrated assessment is used to evaluate how economies, which drive GHG emissions, alter atmospheric and biogeochemical cycles, which then have their effect on economies, environment and ultimately, human welfare. Integrated assessment models are also used to evaluate the consequence of different assumptions and actions through informative feedbacks of those on different socio-economic sectors

Schwanitz (2013) evaluated IAMs and their relevance to climate change assessment and concludes that IPCC assessment reports draw a substantial proportion of their conclusions from IAMs. However, IAMs tend to still have significant gaps in their structures. For example Pauliuk et al. (2017) show how a number of the major IAMs - AIM/CGE, GCAM, IMAGE, MESSAGE, and REMIND, ignore significant components of industrial systems such as material cycles and the life-cycle impacts of technology. These authors conclude that improving these components will likely improve the study and implementation of policy-relevant GHG mitigation options.

Rosenzweig et al. (2017) compares approaches especially for the economic modelling using the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) which enables a multi-sectoral assessment of different risks. The key advantage here is one of using standardized climate variables and socio-economic projections to provide common inputs for projecting future risks, enhancing consistency (Rosenzweig et al., 2017). This consistency allows for the testing of "overlap", competition between sectors, eg water, creating a multi-sectoral risk However, uncertainties in ISIMIP are considerable, (Rosenzweig et al., 2017)there are significant differences in the results from the different models reflecting their different internal parameterizations and structure (Rosenzweig et al., 2017).

IAM simulations and reporting tend , to focus on particular sectors or groups of strongly interacting sectors rather than trying to optimize whole-society approaches – water and energy (Parkinson and Djilali, 2015; Cohen et al., 2014; Spalding-Fecher et al., 2014), in economics (Barker, 2017), biodiversity and ecosystems (Kok et al., 2017; Runting et al., 2017; Wade et al., 2017). These sector-driven approaches try to identify local optima instead of system optima and is therefore inefficient.

Additionally, traditional IAMs in the economics sector fail to capture complexity of the global energy-economy system, the ethics of inter-generational equity, path dependence imposed by introduced technologies, and the politics of climate policy (Barker, 2017). There are few, if any, whole ecosystem and biodiversity models because the subject is so large and complex and such assessments often lack scientific vigour (Wade et al., 2017).

Key research needs with all the IAMs remains the uncertainties within the models, the complexities of the real-world systems they are trying to emulate. Model outcomes are fraught with aggregation bias and is a result of a lack of a necessary level of detail (Sue Wing and Lanzi, 2014). A consensus amongst researchers, it appears, is that IAMs still have a long way to go in order to have confidence in the modelling of climate change impacts and robust adaptation options (Barker, 2017; Runting et al., 2017; Sue Wing and Lanzi, 2014). Even climate inputs are uncertain, leading to propagated error and other types of uncertainty. A system of robust decision making (RDM) is required for any use to be made of the approach.

Alternative: policy framings

Bernauer and McGrath (2016) examined whether it was worth altering the policy framing in order to boost public support for reducing climate risks. They evaluated: 1) An economics co-benefits frame emphasizing the combatting climate change leads to technological innovations and a more prosperous economy, 2) a good society frame which emphasizes the fostering of community spirit through combatting climate change, 3) a health benefits frame in which combatting climate change leads to improved health by reducing pollution and encouraging more active lifestyles.

Other possible policy framings include moral framing (Severson and Coleman, 2015) – not to be confused by a moral framing in its own right – discussed below. Another is a National Self Interest policy frames (Green, 2015). This is essentially a framing from the view of economic efficiency. The benefits of this approach are assumed to be that citizens and governments will realise that GHG mitigation (particularly) will have a positive cost-benefit

Bernauer and McGrath (2016); Severson and Coleman (2015) and Lockwood (2011) all find such alternative policy framings largely ineffective across a range of political and socio-economic spectra. There is no strong evidence for supporting alternative framings of climate policy to address the known risks. Bernauer and McGrath (2016) emphasized that altering climate policy framing away from climate risk, in which the IPCC and scientific community is heavily invested, would pose its own risks by reducing policy interventions on the hazards of climate change.

Climate change policy may have to adapt to the state of uncertainty and evolving climate change conditions (Lawrence and Haasnoot, 2017). Although aspects of the IPCC climate risk frame hold, for example changing flood frequencies in Lawrence and Haasnoot's (2017) paper, the direction of change in terms of an increased frequency and intensity seems accepted, even though the level of uncertainty is high. The emphasis in their paper was that flood managers held a different frame before their intervention, which was influenced by the regulatory environment in which they worked. The key here is that decision-making in uncertain conditions is different to perceiving known changing conditions, such as population and economic growth, along with transport needs (amongst others).

Alternative: moral and ethics framings

A number of papers refer to a moral and ethics framing of climate change. Markowitz and Shariff (2012) and Adger et al. (2017) show how a range of climate change challenges to our moral judgement systems can be overcome by specific and directed strategies. Wolsko et al. (2016) discuss how moral framing, couched in social and political identities, can be used for targeted audience. Reframing climate change issues to be more diverse and inclusive of different values leads to a greater number of changes in attitudes. There are however pros and cons to this approach, including the complexity of correctly segmenting and addressing each (Wolsko et al., 2016). Another approach is to view climate change as a "bioethics problem", which, when viewed from a health perspective, is apparently received favourably by a particularly wide number of peopl (Valles, 2015).

Influence of IPCC risk framing on policy and practice

Risk framing has been implicit in a number of sectors well before the development of the IPCC approach of risk framing – for example in the water resources sector, engineering, in the disaster risk management field, and in different ways, the health sector as it implies medical conditions predisposing a person towards morbid outcomes. Nevertheless, it is possible that with the advent of the IPCC's risk framing, the concepts of risk as they pertain to the terminology of hazard, exposure, sensitivity and vulnerability, have become more widespread and understood as a working concept, especially as it visually defines the interrelationships of these components of the risk framing (see Fig 1.). For example, there is a widespread understanding of the 2°C limit of warming that is considered safe (Knutti et al., 2016). The risk framework needs further development in the meanings of exposure, sensitivity and vulnerability and how they can be measured and altered by various actions. For example, Aven and Renn, (2015) criticize the IPCC concepts of risk as being too narrow and lacking precision. The sections below touch on some of these issues.

While integrated assessment modelling has its uses for understanding possible dynamics of complex interlinked systems, from a climate change assessment perspective these remain less robust under uncertainty. Both the inputs of modelled climate changes and especially the environmental and societal responses to the various pressures exerted by the systems in which they operate, remain highly uncertain (Runting et al., 2017). Researchers are calling for "integrated approaches that incorporate multiple drivers of change and account for multiple sources of uncertainty", as well as studies that identify solutions that are robust to uncertainty (Runting et al., 2017) The consequence of this lack of focus on these complexities, are misinformed assessments of the impacts of climate change, which result in poorly-directed management actions and misallocated funding (Runting et al., 2017; Barker, 2017).

Encouragement of research on vulnerability

As is pointed out frequently, many non-climatic factors shape the vulnerability of societies and their economic assets that are exposed to climatic hazards (Birkmann and Mechler, 2015; IPCC, 2012a), and others. Essential questions remain. For example, Birkmann and Mechler (2015) specifically mention open questions in SREX Report (2012) and IPCC 2014 (WGII AR5) about "how to define and differentiate extreme events and extreme impacts", the role of vulnerability assessments in evaluating climate risk and how different types of urbanization influences risks and comment on the use of scenarios to characterize vulnerability and risk .

Advent of Robust-Decision Making

Risk framing, under uncertainty, conceptually allows an approach that takes into account the "deep uncertainty" by identifying the possibility of scenarios of pathways, which would allow a certain robustness of evaluation outcomes (Hallegatte et al., 2012). This is known as "robust decision making" (RDM). Shortridge et al. (2017), in an example on the development of water resources for agricultural and other development in the northern part of Ethiopia described how long-term performance of planned infrastructure is hard to evaluate without good climate data. They apply a method of RDM which is aimed at identifying the most (and least) influential of uncertainties without carrying additional research (Shortridge et al., 2017), i.e. which uncertainties have the greatest influence on system performance.

Ranger and Niehörster (2012) apply this risk framing to hurricanes in Florida, using a RDM approach. They develop scenarios of plausible futures, generating risk scenarios of long-term hurricane hazards that can inform adaptation. Using this risk characterization, they are able to identify natural variability as the dominant driver of wind-related risk in the coming decade, addressing questions of adaptation across timescales in light of deep uncertainty (Ranger and Niehörster, 2012).

Risk Framing in Policy and Practice

Health: The World Health Organisation (WHO) has adopted specific policy and practice stances of climate change risk framing relating to the increased likelihood of health challenges as a result of climate change (WHO, 2014). The WHO therefore is actively supporting adaptation projects in developing countries. At present these actions have focused on early warnings and early actions, for example on the likelihood of outbreaks of diarrhea, which can be predicted as a function of temperature.

The risks imposed by rapid temperature increases are well illustrated by the the example of the heatwave in Europe in 2004, more than 30,000 died prematurely (US EPA, 2017). In this case, excess deaths start to appear as temperatures rose above 36 °C. By 40 °C, there was a substantial rise in excess deaths. Risk framing works well here – temperatures rising above the danger threshold in the context of Western Europe is the hazard, ways and means of cooling were unavailable creating exposure and those most affected were the elderly and frail (sensitivity).

In response to this understanding of risk, England published a Heat Wave Plan that incorporates the risk of heat hazards at both seasonal and daily timescales (PHE-NHS, 2015). Disaster Risk Reduction was integrated into government planning through a public investment planning and financing strategy in Peru (UNISDR, 2015). Actions recommended in this plan are focused on the most vulnerable segments of society. However, not all government agencies have adopted such a risk framework For example, Bangladesh are adapting to the challenges of climate change through increases in their health services capacity (Government of Bangladesh, n.d.)

Urban Planning: Generally, a trend across the world is one of urbanization, mostly poor people are moving to cities for economic opportunity reasons. Continuing population growth and ongoing urbanization will add about 2.5 billion people to the urban population by 2050 (UN-Habitat, 2016). Many of these will be in economically unequal cities, with high levels of poor living standards and at high risk of the hazards presented by climate change (UN-Habitat, 2016). Garschagen and Romero-Lankao, (2015) uses a risk framing to conclude that existing scholarship has tended to focus on urbanization and increasing exposure to climate hazards whereas other dimensions of vulnerability, that is, sensitivity and capacity for adaptation are relatively poorly represented. The income levels of people strongly affect their sensitivity and inability to adapt, with poor people being most affected (Garschagen and Romero-Lankao, 2015; Miranda Sara and Baud, 2014). These authors conclude that vulnerability as a component of the risk framing needs to be more contextualized and balanced in order to understand the pathways of vulnerability. Countries with the fastest urban growth in Africa and Asia have the highest sensitivity to climatic challenges (extreme events) and lowest capacity to adapt. Urbanisation however offers opportunities for disaster risk management in terms of both policy and practical responses in more efficient ways than might occur in rural areas (Garschagen and Romero-Lankao, 2015; Miranda Sara et al., 2016). Other factors such as social networks, land security, rule of law, governance and others, contribute to vulnerability. These are not captured in the risk framework and data for these aspects of vulnerability are usually scarce or quantifiable.

Agriculture: Agriculture is very closely linked to the vagaries of climate, especially extremes and so climate risk framing is a highly appropriate way of contextualizing challenges to agricultural production. Agricultural management generally is an exercise in risk management that includes more than climate risk (Crane et al., 2010). Droughts, high temperatures, excessive rainfall, flooding, high winds, extreme cold are all climate-related agricultural hazards to which different farming systems are highly sensitive. Agriculture is one sector where the credibility of climate-related information is significantly important to the users (Crane et al., 2010). Adaptation strategies however are often directed towards short-term farm recovering and not longer-term changes (Church et al., 2016).

Possibly more so than any other sector, agriculture collects the data and maps and models its sensitivity to exposure to the different climate hazards. Coping with uncertainty is a well-established requirement of staying in business. Attempts to forecast seasonal and longer-term climate is fraught with uncertainty because of the ongoing inability of seasonal forecasts to develop reasonable accuracy. The agricultural sector constantly reviews these highly uncertain messages and integrates them with other information such as market conditions and other input variables such as labour, energy and consumable materials. In areas of the world where climate is highly variable, seasonal financial losses are common. The agricultural sector likely innovates more than any other sector (see for example (Notenbaert et al., 2017). Smallholder farmers are extremely vulnerable to climatic challenges and generally have insufficient risk-coping strategies to keep them from food insecurity (Harvey et al., 2014).

Ecosystems: There is a large literature considering functional changes in ecosystem and biodiversity integrity concerning climate change, especially with regard to temperature increases. There are relatively fewer that take a climate risk management approach to ecosystems and biodiversity sustainability and conservation, but a few examples could include Kok et al. (2017), Runting et al. (2017), Wade et al.(2017). Kok et al. (2017) consider decisions made under uncertainty and the use of scenarios for forming different policy options. (Prüssmann et al., 2016; Runting et al., 2017) find significant differences in the types of ecosystem services considered and the multiple drivers of change (not only climate) and the multiple sources of uncertainty. There are considerable gaps in the local contexts and few studies that identify solutions that are robust to uncertainty (McCormack et al., 2016; Runting et al., 2017).

Disaster Risk Management: Elements of risk framing have long been within the disaster risk management scope of activity, for example in preparation for volcanic eruptions and earthquakes. These hazards have high levels of deep uncertainty and the realization of an event can have calamitous consequences. However it seems that the concepts of risk management has now developed as a "mainstream concernof the disaster management fraternity in the last two decades (Christoplos et al., 2001). CCA is now viewed as an essential element of DRM and the development of resilience (Birkmann et al., 2013).

The risk framing has encouraged a linking of timescales, bridging the short-term disaster risk that comes from weather events, with long-term disaster risk in coming decades and centuries. Much work on climate services attempts to bridge the gaps between short-term and long-term risk management, including novel research methods to discuss weather within long-term climate (Coughlan de Perez et al., 2015; van den Hurk et al., 2016) . This is also reflected in the Sendai Framework on Disaster Risk Reduction and especially the need for an improved and evidence-based science-policy interface with DRR (Carabine, 2015)

Financial instruments: Historically, risk management portfolios included direct reduction of risk as well as a variety of mechanisms for dealing with residual risk, including risk transfer and risk absorption. In light of the risk framing used by the IPCC for assessing climate change, similar approaches have been suggested to complement direct adaptation, or risk reduction (Mechler et al., 2014). This includes risk financing and risk transfer mechanisms, such as microinsurance, as well as risk absorption in terms of post-disaster assistance and compensation (Lashley and Warner, 2015; Schinko and Mechler, 2017). There are risks "beyond adaptation" regarding financial instruments, especially in developing countries and the use of micro-risk transfer schemes and even sovereign risk transfers, which can be extremely expensive for such countries. A post-disaster financial gap emerges with respect to liabilities, which is best dealt with by disaster risk reduction and management (Linnerooth-Bayer and Hochrainer-Stigler, 2015).

Metrics of Climate Risk: In order for resources to be allocated for the development of climate adaptation and resilience and levels of fairness to be evident in that allocation of resources, a variety of metrics need to be applied in risk frameworks. Scholars have also suggested that subjective assessments of resilience are a more useful measure of capacity (Jones and Tanner, 2015) . An example of this and application in terms of a specific context, is the use of "Local Reasons for Concern", which broke down RFCs to community levels in a practical example in an Austrian study (Hama et al., 2016). This is still an evolving field, hard and unequivocal measures do not yet exist. As with several of the components of the risk framework – exposure (to a certain extent), but particularly sensitivity, vulnerability and resilience have been converted into indices, which are comparative evaluations only (Miola and Simonet, 2014). Even comparisons within IPCC reports can give different outcomes and indicates the necessity of developing a set of unambiguous metrics of comparing climate change impacts, vulnerability and resilience (Nicholls and Seneviratne, 2015). This is an area of substantial future work in the fields of economics.

Challenges to implementation of a risk framing

Challenge 1: Concern vs. Action of Climate Risk

There remains a difficulty in getting the public and political entities to accept the conventional risk framing as well as the magnitude of the problem which results in action (Bernauer and McGrath, 2016; Pew Research Center, 2015). While people acknowledge climate change as having risks and with harmful effects, fewer were committed on what to do about it. People in countries in South America and sub-Saharan Africa were especially concerned about the impacts of climate change, those in the largest emitters China and the USA, were less so (Pew Research Center, 2015). Those in countries with the highest levels of CO_2 emissions per capita expressed fewer concerns than those with lower per-capita emissions (Pew Research Center, 2015). A concern-vs-action gap exists in most of the high-emitting countries, in which the action is the support for their country signing an international agreement limiting GHG emissions. The level of support for action is consistently greater than the concern about the impacts of climate change (Pew Research Center, 2015). The widespread concerns ranged from the likelihood of droughts or water shortages, severe weather, heatwave or long periods of hot weather and sea-level rise are their greatest concerns, with drought featuring strongly in sub-Saharan Africa and South America.

Climate change risk therefore has elements of vulnerability, which in turn are seen through a socio-political lens (Eriksen et al., 2015). How risk is perceived depends of the political and social environment of the recipients of the messaging (Eriksen et al., 2015). Despite this, others see risk framing as needing a generic and common framework (Hammill and Tanner, 2011).

Challenge 2: Vulnerability and Exposure information

Effective adaptation is only possible when the factors that threaten or facilitate the threat are well known. According to Jurgilevich et al. (2017), the individual components in risk and vulnerability assessments are commonly not well known. In two thirds of studies by these authors, most have not considered both vulnerability and exposure dynamics, while vulnerability is considered more often than exposure and mostly separated socio-economic vulnerability from biophysical impacts.

The poor availability of data and methods results in particular challenges for socio-economic and spatial assessments (Jurgilevich et al., 2017). Multiple methods, uncertainty and sensitivity analyses, multiple pathway approaches and greater stakeholder involvement are aspects that need addressing. Vulnerability tends to be dynamic and leads to increasing uncertainty (Jurgilevich et al., 2017). Uncertainty however can be reduced by producing a range of alternative future pathways and plans for adaptation should be considered against the full range of alternative scenarios, rather than just the most plausible scenario.

Poor availability of data and methods also affects the least developed and vulnerable of countries (Shortridge et al., 2017; World Bank, n.d.). Methods may have mismatches in time horizons, with future climates evaluated along with current socio-economic conditions, with Jurgilevich et al., (2017) reporting about half of studies evaluated in their paper presenting this condition. This can have consequences that are distributed disproportionately amongst population groups (Cutter, 2017).

Jurgilevich et al. (2017) argue for a closer examination of exposure, vulnerability and hazards in a certain place and at a certain time, that is, the evaluation must be highly context-specific. The IPCC noted that no single metric of vulnerability can describe the diversity of key vulnerabilities which included magnitude of impacts, timing, persistence and reversibility, likelihood (probability), potential for adaptation, distributional aspects and importance of systems at risk (Carter et al., 2007). Researchers also caution against the development of unified cross-disciplinary metrics, as this could undermine the information captured through methodological pluralism (Olsson et al., 2015)

Challenge 3: How to expand the scope of adaptation responses

he majority of adaptation literature focuses on what Bassett and Fogelman (2013) calls “adjustment adaptation”, which are incremental adaptations to the prevailing trends of climate in the context being considered. They note that a very small share (~3%) of literature concerns just the social roots of vulnerability and the necessity for political-economic gain (social justice). The authors are questioning whether adaptation to the climate risk is the right focus, instead of socio-economic development. (Wise et al., 2014) suggest that this focus on incremental adaptation is due to the fact that adaptation pathways do not often consider the wider socio-political context, including path dependencies, vested interest, and global change. Others are taking a different approach. Small Island Developing States (SIDS) in the Pacific Ocean consider that resilience to climate change risks is best approached through the development in the sectors of health, education, water and sanitation, social assistance, energy, agriculture, fisheries, forestry, tourism, mining, culture, environment, transport and infrastructure, rather than focusing purely on risk (Pacific Community, 2016). This is a movement from a “risk first” to a “development first” approach.

Lorenz et al., (2014), in response question this viewpoint but note that adaptation to climate change is a highly policy-relevant field which needs current information to be useful and that better tools and a better understanding of climate change adaptation research is required. Lawrence and Haasnoot (2017) address some of these issues by Dynamic Adaptive Policy Pathways (DAPP) and review some of the enabling requirements of adaptive planning. Again, context factors are critical. The adaptation sub-frame is itself evolving, in which ‘resilience’ is now developing its own narratives around scientific research and policy-making (McEvoy et al., 2013).

Conclusions

The framing of climate risks as a means of conveying the impacts of climate change, and to guide the development of appropriate responses, is one of the significant developments of the IPCC assessment reports and guides the way for future research. As a means of communicating with the UNFCCC, governments, the scientific community and the wider public, there is a standard and common message:

- Climate change risk framing emerged in the IPCC assessment reports as a narrative of the climate change impact, firstly just a descriptor in FAR and SAR, but evolved to incorporate vulnerability in the TAR.
- AR4 consolidated the concept of climate risk framing around hazards, exposure and vulnerability and this was further advanced in terms of likelihood of occurrence in AR5 and presents the core model of climate change impacts.
- This framing continues to be the dominant mode of thinking and action around research of climate risks, although other frames have been proposed.
- The general approaches for climate risk management have not yet moved beyond the climate change policy responses or the desire to have an integrated adaptive focus, attesting to the ongoing lack of understanding how different socio-economic sectors are impacted or are vulnerable to climate change impacts, as well as an understanding of the interrelatedness of the different sectors concerned. This will continue to be an area of significant research including representation of some aspects that concern the “softer” elements of human interrelationships.
- Adaptation is and remains a key area of research (Burkett et al., 2014)
- In the future, more emphasis is likely to be placed on understanding and developing metrics for exposure but particularly vulnerability, in its different contexts.

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