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# Climate science in climate security scenarios

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**Abstract** The climate is changing and this will have consequences across the globe, affecting all areas of the natural and human environment in complex ways. One tool for exploring the complex relationship between climate change and security is to use a scenariobased approach as means to develop plausible rather than probable narratives. This approach can explore the range of uncertainty, and help policymakers to visualise the potential consequences of climate change. Scenario methodology has been most comprehensively developed for use in business planning and there are some differences in the way scenarios work for climate security. The most notable is the fact that there is a physical modelling basis for climate projections. This means that the uncertainty range associated with at least this one aspect of the scenario can be systematically sampled. This paper reviews how scenarios have been used in the climate security literature to date, in particular in the grey literature. The integration of climate projections is explored in detail, as the main distinguishing feature of climate security scenarios over other scenario types. Few climate security scenarios have been developed to date, but all those included in this review, regardless of the differences in national conditions, regional climate change and potential responses, came to very similar conclusions. This was despite differences in the changes in climate and non-climate drivers, or differences in the scenario approach and audience. A more systematic and scientific approach to developing the scenario drivers and narratives is recommended, and successfully embedding changes in climate within the socio-economic context, through better integration of inter-disciplinary expertise, is critical.

## 1 Introduction

Climate security is the study of the impact of climate and climate change on the security of affected communities. This can mean the affect of climate on conflict, but also encompass the softer definition of security. In this context security can be defined as “the assurance people have that they will continue to enjoy those things that are most important to their survival and well-being” (Soroos 1997). One approach to evaluating the potential impacts of climate change on security is to use scenario planning methodologies.

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Scenario planning was first developed for military applications, but was later appropriated by business analysts, primarily Shell, as a tool for organisational learning (Shell International 2003). Scenario planning is used as an alternative approach to traditional predictive strategic planning. In scenario planning, a range of uncertain futures are assessed, and by developing narratives or storylines to illustrate this range, organisations are able to assess their ability to respond to the situations within the scenarios.

Scenario planning is used to study the implications of a range of plausible futures, without assigning probabilities or being overly constrained by uncertainty. Scenarios can be used to support decision making, but may also be used simply as a tool for better understand relationships and causal processes within a system. They can be used for risk assessments or contingency planning, identifying threats or testing options for resilience and adaptation responses.

In recent years scenario planning has become increasing popular (Mietzner and Reger 2005). It is seen as a means of improving resilience and adaptability in a rapidly changing world, most of which is beyond the influence of the organisation itself. It is therefore unsurprising that this kind of approach to planning is beginning to be applied to assessments of climate change, and specifically the security implications of a changing climate.

Isolating climate change from other changes or events is impossible, and probably not particularly valuable for the policy-maker. Using scenarios allows analysts to combine different changes together and to systematically alter different drivers of change, to test the sensitivity of the outcomes to different parts of the system. As a result climate security scenarios tend to be multivariate in that they contain information about socio-economic factors in addition to information about climate change and its impacts and changes in future greenhouse gas emissions (Parson et al. 2007).

An important feature of climate security is that it combines understanding of changes to the earth's weather systems and impacts, which are generally explored through numerical modelling, and the socio-economic system dynamics of a region. Scenario planning has not traditionally been used with this combination of natural and social science input, and so makes climate security scenarios are particular interesting case to study.

## 2 Scenario methodology for climate security

Scenarios are individual storylines which provide a convincing and plausible version of a possible future. The persuasiveness of such narratives has the potential to influence the thinking of the reader, and indeed is designed to do so. The complexity of the climate science and its interaction with human and environmental systems presents a challenge when building climate security scenarios and that there is unlikely to be a single optimal scenario design approach. This is recognised in the academic literature on general scenario techniques, where emphasis is placed on the need to design scenarios in light of the decisions that they are required to inform (Lempert 2012; Schwartz 1992; Van Notten et al. 2003). For climate scenarios in particular, Parson et al. (2007) identify four types of global change scenario, based on the main uncertainties in the climate system and socio-economic factors. These are: 1. Emissions scenarios; 2. Climate scenarios; 3. Scenarios of first order impacts; 4. Multivariate scenarios for impact assessment. In the process of understanding climate change, the first set of scenarios set out the potential emissions pathways that could be followed; the second set represents the range of climate model projections consistent with an emission pathway; the third are a set of impacts scenarios consistent with a particular climate model projection. The fourth stage is where the first order impacts interact with human systems, and there are a further range of possible outcomes consistent with each set of impacts. At each stage in the development of our understanding of climate change, the range of plausible outcomes widens. This is an important point in the distinction of climate security scenarios from other security types. There is a wide uncertainty range associated with the increasing complexity and sophistication of understanding of climate change science, but it is possible to document and systematically sample that range, which can then be used as the climate change driver of a scenario set.

The application of scenarios methodology for climate security may require a modification of the method. There are three factors that suggest this. The first is that it is possible, through numeric modelling to develop a set of climate impact futures, which systematically explore the range of plausible futures across the uncertainty range. However, it should be noted that although the systematic sampling of the range of uncertainty at each stage is an ideal, it is not one that is currently carried all the way through to the first order impacts in many instances. The emission scenarios are sampled through the SRES and now RCP, approaches. The World Climate Research Programme (WCRP) Climate Model Inter-comparison Project (CMIP), provides a framework for systematically sampling climate model projections consistent with these emission scenarios. These efforts are not perfect, and cannot capture the full range of uncertainty, but do make a concerted effort to do so within the limits of feasibility. However, the same systematic approach has been less evident in impacts models and studies. Here it is much more common for a very small sample of driving climate model projections to be used, often for a single climate impact model. Thus the additional uncertainty associated with the use of different impacts models is also rarely sampled. Attempts are being made to address this through the Potsdam Institute for Climate Impact Research ISI-MIP project, which aims to provide quantative estimates of impacts and uncertainties, for different sectors and from multiple impact models. However, this is a very recent development, and has not been available to the climate security scenarios studies in the current grey literature.

The second factor that is particular about climate security scenarios is that the climate is a physical system. Simply put, climate change follows the laws of physics. Climate change is not just about what, but also when and in what combination. Events may happen sooner or later than anticipated, but will not occur out of order, and combinations of events will not occur concurrently when there is no physical mechanism for doing so. This is different from socio-economic factors, which could, in theory, occur at any time. So for example, nations could agree on an Arctic treaty now, in the future, or never. Nations could adopt aggressive expansionist philosophies, or develop high levels of environmental protectionism, but there is a window of time over which the Arctic will melt and this will not occur faster than the rate of change of the physical processes within the earth system that cause it. This provides an advantage to scenarios of climate security, in that there are aspects of the scenarios, i.e. the changes to the physical system, that can more easily be constrained, provided that the appropriate expert input is provided to the development of the scenario.

In addition to advantages of including climate information in scenarios, there are some aspects that mean particular care needs to be taken when handling information about the climate as part of the scenario. The climate naturally varies from year to year and over decades, often masking the longer term trend of climate change. In trying to identify the impacts of climate change, it is necessary to do so within the context of the natural variability of the climate. The scale of change anticipated, relative to natural variability, has profound implications for the ability of systems to adapt. Mixing up weather and climate is a common error. This can be addressed by being particularly clear about the question being asked; step one in the scenario development process. If a scenario is being developed to understand the relationship between the environment and security, this represents a different question to one about whether climate change will have consequences for security. The difference is the attribution of the drivers of the scenarios, whether they be climate or climate change.

Being clear about climate change and climate variability matters when offering policy advice. For example, if the risk of flooding in a given area is occasionally high, but not projected to rise under climate change, a recommendation to mitigating climate change would not be appropriate as a response to limit flood risk in the area. Mitigating climate change may be important for many reasons, but it will not tackle the flooding. The second reason this matters is that it is important for the scale of the impact expected. If precipitation is projected to reduce, then this may affect rain-fed agricultural systems, which could have implications for food security. However, if the reduction in precipitation is far lower than the natural variability, the impact could well be negligible. The security conclusions may therefore be different in the light of an understanding of the scale of change.

One option to help understand the relative importance of climate change and variability, is to look at the 'time of emergence' (Giorgi and Bi 2009). This is the time at which the climate change signal exceeds a given percentage of the natural variability of the climate (usually one standard deviation). This information can be used to assess whether the changes described have any significance relative to historic weather patterns, or if the trend will become significant within the timescales of the study.

## 3 Climate security scenarios

There are a number of examples of the application of a scenario approach to climate security analysis. These studies exist only in the grey literature, and take a variety of approaches. Although they largely follow the standard framework to developing the scenarios outlined in section 1, the interpretations of the driving factors and differences in the way both climate and non-climate factors are assessed, make the scenarios themselves very different. This might be expected given the variety of audiences for which they were written. However, one feature that is rather remarkable is the similarity in the outcomes and conclusions from the studies themselves, despite the sometimes quite significant differences in the narratives.

### 3.1 Global studies

#### *3.1.1 Case 1: a conflict driven narrative*

One of the most comprehensive climate security reports that included the use of scenarios was produced by Schubert et al. (2008) as part of the German Advisory Council on Global Change (WBGU), and titled, 'Climate Change as a Security Risk'. This extensive report on climate security includes a set of 'conflict constellations'. It was developed in conjunction with climate scientists and as a result is well grounded in climate science. It avoids unsupportable or sensationalist statements on future climate that can sometimes occur. As a result of the input from climate scientists and other experts, differences between different drivers of change are clearly identified and explained. Not every kind of social and environmental change is called climate change, and the relative importance of different kinds of changes is clear. This report also drew on expert understanding of the latest thinking on the link between conflict and environmental change. Few other scenario studies included in this review addressed the uncertainty in this relationship, and rather tended to weave a conflict dimension into the narrative, without any background context behind these assumptions (Maas 2011; Maas et al. 2010; Schwartz and Randall 2003).

However, despite the detailed input from climate scientists, this expertise is not used within the scenarios to sample the uncertainty in climate projections or climate impacts; differences in climate change at a regional level; or uncertainty in other changes (such as demography, technology, etc.). Instead the report sets out four 'conflict constellations' which summarise a set of four climate impacts. Each of these generates a scenario of 'confrontation' and one of 'cooperation', so that only the policy response is varied between scenarios. No other potential change factors, such as demography or technology, were varied to create additional scenarios.

In each of the four conflict constellations, poor governance and lack of cooperation lead to conflict; good governance and cooperation leads to a management of the stress, and an adaptation to more challenging circumstances. One pair of scenarios centres around water availability and glacier melt in Peru. The scenarios illustrate that there is a potential for conflict as a result of the change in water availability due to glacier melt, but that this is not inevitable. Neither scenario makes use of the information in the climate projections on rate of change, or quantifies that change. The result is that although each scenario may be plausible, (the importance of effective cooperation frameworks for allocating water resources to avoid conflict is supported by the literature (Bernauer and Siegfried 2012; De Stefano et al. 2012)), it is not clear how achievable the success of the governance and cooperation measures really are in the face of the scale of the challenge that climate change poses.

### *3.1.2 Case 2: a risk-based perspective*

One scenario-based study that did use different climate change projections to generate climate security scenarios was conducted by Campbell et al. (2007), for the Center for New American Security (CNAS) and the Center for Strategic and International Studies (CSIS). Their report is called, 'The Age of Consequences: The foreign policy and national security implications of global climate change'.. This study also had high level input across disciplines, including climate scientists, security analysts and other experts. It aimed to look beyond the most probable levels of climate change according to the latest projections. They developed three scenarios based on three levels of climate change which they labelled 'Expected', 'Severe' and 'Catastrophic'. These three scenarios were clearly defined in terms of timescale and scale of change.

The key advantage of this approach is that it bases the scenarios on internally consistent climates which have a well-defined timeline and scale and which deal with the range of climate projections from a risk-based perspective, rather than just assuming a single 'most likely' outcome. The assumptions behind the climate projections are also clearly stated. So, for example, in the case of the catastrophic climate change scenario, a complete shutdown of the thermohaline circulation (THC) is assumed. This is described as a low-probability, high-impact event, which would not necessarily be the consequence of a rise in global average temperature, but is consistent with it, and makes an interesting extreme case to explore.

However, despite the rigour with which the climate change projections have been sampled, the climate impacts associated with them have been less transparently dealt with. Each scenario takes a perspective on the impacts and security consequences of climate change for each of the regions of the world. However, the link between climate change and impacts is often an uncertain one, and the full impacts are only really clear in the context of the local systems and vulnerabilities. This study (Campbell et al. 2007), like the one by Schubert et al. (2008), starts from the perspective of a change in climate and looks for consequences, rather than analysing the climate on the basis of regional vulnerabilities.. General points about water availability and food scarcity are deduced from the changes in climate and, combined with the impacts of sea level rise and severe weather events, are used to derive a security narrative. However, in common with many other security assessments of this kind, it is during this narrative that the scale of the impacts and their potential range is omitted in any detail. As with other such studies, this makes it difficult to see where assumptions have been included.

All three of the scenarios identify the key consequences of climate change as being related to food security, water availability, land loss and degradation and weather-related disasters. The difference in the scenarios is mainly the extent of the challenge.

### *3.1.3 Case 3: a systems vulnerability approach*

A study that does begin with the system vulnerabilities, and then goes on to evaluate the potential impacts of climate change on this basis was conducted by the Global Business Network (GBN) (2007). This report was not labelled as 'climate security', but it dealt with the impact on human security systems, such as water, economics and insurance.

This particular study attempted to assign probabilities to a range of geophysical effects of climate change, from higher maximum temperatures to more intense precipitation events and increased Asian monsoon variability. Rather than using these impacts to deduce the impact on human and environmental systems and from there the socio-economic responses and the security threat; the report examined the climate impacts from the perspective of the vulnerability of systems, and used this to develop a list of systems vulnerable to climate change, illustrated with a narrative. This focus on the vulnerability of systems is a useful way to approach climate security, as it better captures what parts of the climate are critical to security.

The study used scenarios to illustrate the report findings with plausible storylines, each described as a 'what if'. This sort of approach is the most basic use of scenarios, and there was no attempt to systematically vary the key drivers of change to sample a range of outcomes. The narrative description acted simply to illustrate how the impacts described could be played out.

One point to note about this study, is that unlike the previous two studies, most of the threats described are not climate change at all, but other environmental or resource related changes, and no attempt is made to distinguish between these different types of stresses. So for example, one climate security vulnerability identified is water availability. In this case the 'what if' scenario describes an event where a Chinese industrial complex dumps toxic sludge into the Brahamaputra river, sparking a regional conflict over available water. This might be a plausible security scenario, but has little to do with climate change. As discussed earlier, in some ways this may not matter, as the conclusions and narratives do tell us something about security, but it is important to distinguish the difference when thinking about appropriate responses to reducing the security threat.

One aspect of this study that is shared amongst all three of the studies included in this review so far is that although specific changes in climate are identified, they are quite general in nature and their relationship to impacts is also general. For example, in the GBN report, one change in climate identified is 'an increase in summer drying over most mid-latitude continental interiors', and the associated impact is given as decreased crop yields. This statement masks a range of projections from climate models, uncertainty in the response of crop yield to summer drying, and does not discuss the scale of change or the timescale. Changes in temperature, length of growing season and extension of agricultural land areas will all affect crop yield in mid-latitudes, along with physiological changes to plants in response to $CO_2$ fertilisation, which may affect water demand, amongst other things. So although this study claims to start with vulnerabilities, which is a good way to identify the important aspects of climate and impacts to a particular system, the climate change and impacts assumed are not necessarily appropriate to that system. This affects the validity of the conclusions, the plausibility of the narratives and the range of uncertainty sampled.

#### *3.1.4 Case 4: an extreme climate narrative*

An example of a very different approach to developing a scenario to illustrate climate security impacts is a narrative by Schwartz and Randall (2003), entitled ‘An abrupt climate change scenario and its implications for the United States national security’. This is a single scenario which attempts to ‘imagine the unthinkable’. This scenario is based around a rapid (within 10 years) collapse of the thermohaline circulation (THC). As with other scenarios the aim was not to describe the most likely outcome, but rather a plausible one; to dramatise the impact climate change could have on society. Indeed, the extreme nature of this scenario does make it particularly dramatic. This scenario exercise generated significant media coverage at the time it was released, as well as extensive criticism (Shearer 2005).

There are a few aspects of this scenario that make it interesting. First of all it is extreme, both in the scale of change, but also more especially in the rapidity of the change. Despite this, the characteristics of the narrative are very similar to other scenarios. The three main drivers of conflict within the narrative are resource constraints around food security, availability of fresh water and energy supplies. The recommendations for action include identifying no-regrets strategies, such as enhancing capabilities for water management and rehearsing adaptive responses, which are reflected in all the studies included in this review. One conclusion made in this report which is unusual however, is the call for an exploration of geo-engineering options to control the climate. This is no doubt related to the philosophy of ‘imagining the unthinkable’ behind the scenario, but this kind of recommendation highlights the need to accurately identify what is climate change, before embarking on drastic action to address it.

### 3.2 Regional studies

In addition to global climate security scenarios, a number of regional scenarios have been developed. These raise the possibility of developing a more detailed analysis of how the changing climate interacts with the specifics of local systems and their vulnerabilities.

One example of this kind of analysis is a scoping study on the security implications of climate change in the OSCE region and beyond, entitled ‘Shifting Bases, Shifting Perils’ (Maas et al. 2010) and the follow up more detailed scenario report ‘Climate Change and Food Security in Eastern Europe’ (Maas 2011).

In the scenario analysis for Eastern Europe (Maas 2011), the background assessment made in the scoping study was developed into a set of four scenarios. These scenarios looked to 2050, but some provided quite detailed climate impacts on much shorter timescales. In the case of one scenario, a climate-induced food shortage over a 2 year period from 2018 to 2020 was included. Although a 2 year weather trend would not necessarily be the result of climate change. These detailed weather and climate events were often not reproduced in the scenario which had matching levels of climate change, and there were a number of other differences between the scenarios beyond systematic variation of the climate and market drivers.

A set of climate change and security scenarios for Middle America (three scenarios, Carius and Maas 2009a), Indian-Pacific Ocean Island States (two scenarios, Carius et al. 2009a) and South East and South West Asia (Carius and Maas 2009b; Carius et al. 2009a), were produced for the Directorate-General External Relations of the European Commission. These studies take a similar approach to Maas (2011), in that they set out the regional context, then the climate change trends and impacts and finally assess the security consequences through a set of scenarios. The variations in the scenarios for each region are not driven by differences in climate change or impacts, but by differences in socio-economic response. As with the scenarios developed for Eastern Europe (Maas 2011), the basic assumptions of climate change are that it will negatively impact security of access to food, water and energy. The Indian-Pacific Ocean Island states scenarios also include sea level rise and its effect on land availability, coastal infrastructure and maritime borders, which is critical in this region. This is an example of the specific vulnerabilities of the region being accounted for in the development of the scenario.

In all the scenarios the scale of climate change relative to other stresses and to natural variability is undefined, and the timescales for change, critical in an assessment of adaptability, are not considered. The conclusions of these scenario reports are again very similar to other reports based on a general assumption that climate change will lead to reductions in food, water and energy security, and tensions over resources and land under more difficult economic conditions as a result of climate change. The authors' recommendations include further research into regional climate change, impacts and vulnerabilities, including environmental dynamics in planning and prioritising risk management and reduction. Adopting no-regret adaption measures and improving regional and international cooperation over cross-boundary issues are also highlighted.

## 4 Scenario findings

Nearly all the climate security scenarios included in this report identify the key threats of climate change as related to food security, water availability and weather-related disasters. These then affect economic prosperity, migration and energy security, and through a combination of these threats, increase the potential for unrest and conflict. These conclusions appear in every scenario, regardless of the region, the type of climate change being considered (whether it is sea level rise or increasing temperatures, for example), the audience, the driving question or the scenario approach. The extreme 'imagining the unthinkable' scenario generated by Schwartz and Randall (2003) produced similar conclusions, as did the extensive German Advisory Council on Global Change (WBGU) scenarios (Schubert et al. 2008) and the climate change driven scenarios by Campbell et al. (2007).

The policy response recommendations of the scenarios are also similar. Most of them include: improving the predictive power of climate models; creating vulnerability metrics for countries at risk; preparing adaptive responses to climate change and engaging in mitigation activities. National, regional and international cooperation, good governance and investment in technology key are also identified as important in most scenarios.

The similarity between conclusions around the drivers of insecurity (and potentially conflict), leads to two alternative conclusions about the usefulness of these particular scenarios in climate security planning. The fact that the same drivers (food, water, energy, and to a lesser extend land and transport) are identified repeatedly under a large range of climate outcomes could be because these are robust findings regardless of how the climate changes or where. The alternative conclusion is that the lack of subtlety in the interpretation of the consequences of a changing climate, and the detail of what this means for impacts on specific vulnerabilities of systems, leads analysts to make the same broad generalisations again and again. To escape this kind of 'group think' is a very good reason why scenarios are often used. The selection of the key drivers of change, and the way they are changed to develop each scenario, can be used to break out of the mould of common assumptions about what the future will be like, to explore a wider range of plausible outcomes. One of the key benefits of scenario planning is that there is no requirement to use only more robust, but essentially general assumptions about the future; it is also possible to explore how the detail will play out in new and surprising ways.

All the scenarios examined in this review drew the same basic conclusions on the impacts of climate change, regardless of whether the climate projections were varied as part of the scenario, as in Campbell et al. (2007), or were used as underpinning of evidence on which to build the scenarios, as in Schubert et al. (2008). None of the scenarios explored any of the uncertainty in impacts or questioned any of the simplifications used, such as, for example, the relationship between, precipitation and temperature and crop yield. The best scenarios provided detail on the relationship between regional changes in the climate and local systems, and used these to develop more detail in the narratives, increasing the plausibility of the storylines. The scenario on water use in Peru in the WBGU report (Campbell et al. 2007) is a good example of this. However, these case studies were cherry picked to highlight where climate change would lead to the assumed insecurities. In the Peru case study it was designed to illustrate where climate change would reduce water availability. It does not follow that in all cases, in all regions, climate change will have a negative effect on water availability.

If a wide range of scenarios reach similar conclusions, then it might seem to follow that these conclusions are robust to the differences in the scenarios, but in the case of climate security, there is the possibility that parts of the narratives are subject to bias in their selection and development.

Another similarity between the studies in this review is that all the scenarios showed increasing levels of threats for increasing amounts of climate change, but there was little commonality that allowed the scale of threats to be compared between regions. This might be expected from such a diverse set of scenarios, but even for the set of regional scenarios generated for the European Commission (Carius and Maas 2009a, b; Carius et al. 2009a, b), the absence of a sense of scale of the climate impacts included in the narrative made this difficult. As already discussed, a scenario does not have to be probable, only plausible, so it is difficult to see what would prevent the inclusion of some plausible, physically consistent examples of the scale of climate impacts.

Combining a sense of scale of climate impacts relative to other changes, with more detail on the timings of events or changes in the long term trend, would also help establish which aspects of the scenario are related to climate change. The need to mitigate climate change was mentioned as a recommendation in every report, but not all of the scenarios actually described climate change related narratives. Many of described impacts, that while examples of the consequences of unsustainable activities, were not climate change (GBN 2007). Others described specific events that were essential weather and that could not be attributed to climate change, or were not necessarily consistent with the climate signal as currently understood (Maas 2011). None of the scenarios made use of an evaluation of time of emergence (ToE) of the climate signal over natural variability to identify when a scenario really represented a climate change outcome, as opposed to weather. In addition it was also not always clear from the narratives whether the level of climate change described was far enough in the future to be something that could be affected by mitigation activities.

Finally, including information about the scale of change in the scenario, and the timescale over which it may occur, would make the scenarios conclusions more useful, as it would mean that the socio-economic and security responses could be better evaluated. Some of the scenarios explore options for cooperation and effective governance measures to manage resource scarcity, or cope with humanitarian crisis. However, the value that the scenarios may have for drawing policy-relevant conclusions is undermined if the feasibility of taking effective action cannot be assessed, due to the lack of detail in the scenario.

## 5 Conclusions and recommendations

The existing climate security scenarios are the first steps in beginning to address the issues of climate change for security. Like all scenario development this is a challenging process, but for climate security there are particular challenges, as the examples highlight.

The development of scenario methodology in general, and the examples of the application of this methodology to climate security suggests a framework by which future climate security scenarios could be developed. Adapting from the approach by Schubert et al. (2008) and Maas et al. (2010), the follow steps and guidance is recommended for future climate security studies:

Step one: Define the question

As for all scenarios, the purpose of the task needs to be established first. In addition it is important to be clear about why a scenario is the best approach. At this stage the question of whether the scenarios are to explore climate or climate change can be addressed.

Step two: Identify driving factors

This includes both the climate and non-climate drivers. The most important thing to do here to ensure that the full range of known variation in the drivers is systematically mapped. This is true for both climate and non-climate drivers, but one of the advantages of developing a climate security scenario is that much of this mapping may already have been done. The input of climate science expertise, as well as social science expertise is critical at this stage. It is not enough just to take 'off the shelf' climate projections, without addressing the suitability of these projections to the application, how representative they are of the uncertainty range (including significant tipping points), or whether they represent an internally coherent narrative of future climate.

Step three: Scenario projection and boundary mapping

This stage is particularly dependant on constructive and participatory interdisciplinary cooperation. The combination of the climate and non-climate drivers is a non-trivial task, as each has the potential to impact on the other. Identifying vulnerabilities to climate, for example, may alter the way the climate aspects of the scenario are drawn out. Again, at this stage the systematic sampling of the boundaries of the uncertainty space explored are important, and this requires input from experts from every discipline to confirm that from their perspective the scenarios do so. Successfully embedding the climate changes within the socio-economic context is critical.

Step four: Condensing the scenarios into consistent narratives

It is during the development of the narratives that inconsistencies have the potential to arise. Again taking a systematic approach and having full participation from all the disciplines involved is required. The narrative aspect of the scenario is what gives it its impact on the reader. The more vivid and engaging the narrative, the more likely it is to dominate in the mind of the reader. It is at this stage that the responsibility to remain dispassionate in making decisions about inclusion and the need to be disciplined in defending both the credibility of any detail and the contribution it makes to exploring the range of uncertainty is vital. All the experts involved in the process need to be convinced that the final narratives do this, from the perspective of their expertise.

Scenarios have been developed as a useful way of exploring the challenges of the future, and have been successfully applied in a number of areas, particularly in business. Their application in climate security is relatively new, and there are limited examples in the grey literature. This new application does bring new challenges, but there a number of advantages. The main advantage for climate security scenarios is that it is, in part, informed by our understanding of physical changes in the atmosphere, which are themselves systematically modelled and sampled. Whilst climate projections are uncertain that uncertainty is, at least to some extent, bound, making scenarios an ideal tool for exploring a set range of future outcomes. The main challenge is that it requires cooperation across the physical and social science disciplines, which is a particularly challenging task. However, the importance of understanding how the large and potentially dramatic changes to our climate that we are expecting in the coming decades, cannot be under-stated. The challenges of communicating across disciplines must be faced and using scenario development as a means to do this is an excellent start.

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