Limits to adaptation to climate change: a risk approach

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Current Opinion in Environmental Sustainability

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Current Opinion in Environmental Sustainability

Limits to adaptation to climate change: a risk approach

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As attention to adaptation to climate change increases, there is a growing call for adaptation approaches that focus on risk management. There is also greater recognition that the rate and magnitude of climate variability and change may exceed the limits to adaptation of socio-ecological systems. We offer an actor-centered, risk-based definition for adaptation limits in social systems. Specifically, we frame adaptation limits as the point at which an actor's objectives cannot be secured from intolerable risks through adaptive actions. These limits are significant because exceeding a limit will either result in intolerable losses on the affected actor or system, or precipitate a discontinuous (or transformational) change of behavior by actors. Such discontinuities in behavior have implications for the distribution of risks, with potentially significant governance consequences. We further argue that some adaptation limits are dynamic through time. We conclude with recommendations for further research into adaptation limits and challenges to risk governance.

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Current Opinion in Environmental Sustainability 2013, **5**:xx–yy

This review comes from a themed issue on **Open issue 2013**

Edited by **Rik Leemans** and **William D Solecki**

S1877-3435/$ – see front matter,

http://dx.doi.org/10.1016/j.cosust.2013.07.005

Introduction

As the need for adaptation to climate change impacts becomes increasingly apparent and the evaluation of adaptation choices becomes more detailed and sophisticated, there is growing support for pursuing risk-based approaches to adaptation decision-making [1–4]. From a risk management perspective, climate change alters the magnitude and distribution of climate-related impacts and generates new risks for people and ecosystems. Much of the current discussion about adaptation and risk is focused on assessing the likelihood and magnitude of impacts and the associated communication challenges (e.g. [5]). But the broader field of risk research has addressed issues such as the social processes by which actors identify and negotiate which risks to manage, what is known and not known about these risks, the strategies available to manage risks, and what are acceptable costs or tradeoffs. How societies debate and decide on adaptation choices and priorities closely resembles the way in which complex risks are managed [6].

In its focus on the objectives of adaptation, the discourse on climate risks foreshadows the issue of limits to adaptation [7,8,9••]. Understanding the nature of limits to adaptation requires greater attention because of increasing evidence that greenhouse gas mitigation efforts will not be sufficient to prevent significant global climate change [10••,11,12•]. Therefore, climate change will increase stress on natural and human systems, put pressure on adaptation options and increase the likelihood of exceeding limits to the capacity of social actors to adapt. While all human and ecological systems have some capacity to adapt, there are likely to be limits to that capacity in all systems. As a consequence, radical discontinuities of behavior and system-states may be expected, including for instance migration or species extinction. Such discontinuities may represent catastrophic losses for specific communities, as well as the redistribution of risks for the actors and systems affected. They may also have wider systemic effects through complex feedbacks and teleconnections in socio-economic and natural systems. In general, we believe adaptation limits will be associated with significant economic, cultural, or other losses for certain social groups. We argue below that an adaptation limit does not signal the end of the adaptation process. Carefully planned and managed transformational adaptations on the basis of the redefinition of objectives by actors can result in more resilient management and development pathways.

We see significant complementarities between an emerging focus on risk-based decision-making and the developing attention to adaptation limits. These complementarities suggest that connecting these dialogues can be valuable for adaptation research and practice. This paper addresses the objectives of climate adaptation, arguing that the aim of adaptation is to reduce risks to existing valued social objectives, such as standards of flood protection for residential areas. We then argue that the concepts of adaptation limits and transformational adaptation are useful extensions of the established risk management

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framework. Following this, we articulate a definition of limits to adaptation that takes as a starting point the social actor managing risks to valued objectives through adaptation. We argue that some limits may be dynamic over time and make a distinction between 'soft' and 'hard' limits. We conclude with some reflections on broader risk governance implications.

Climate risks and the objectives of adaptation

While there are many definitions of risk, they all share three common elements: first, outcomes that adversely affect what people value; second, the probability of their occurrence; and third, a formula for combining the two [6]. This insight about the integration of values and probabilities is critical for the debate about the objectives of adaptation to climate variability and change. Adaptation is understood in vulnerability research as seeking to secure 'valued attributes' [13]. Values are also widely acknowledged to play a significant role in defining adaptation goals [8,10••,21••]. As Hartzell-Nichols ([14]:690) argues, ''Adaptation is fundamentally an ethical issue because the aim of adaptation is to protect that which we value.'' Such valued objectives could be health, safety, security, or a livelihood. Hence, the greater the perceived risk to an objective, the greater the demand for adaptation to manage the risk. In this sense, the objectives of adaptation are consistent with prevailing social, cultural, or economic values and goals. Expressions of these may be codified in laws, established in governance practices, or anchored in cultural norms and traditions. These objectives may relate to specific outcomes, such as protection from fire risk, or focus on social processes, such as assuring cultural continuity in a place. For example, through the US regulatory process, adaptation involving water resources may be expected to reflect the objectives codified in the US Clean Water Act ''to restore and maintain the chemical, physical, and biological integrity of the Nation's Waters.''

Risk management has a long history of mediating value differences in social controversies surrounding risks ranging from nuclear power to genetically modified organisms. A central finding from these efforts is that risks differentially affect particular actors and groups, among whom exposures, attitudes, and capacities to manage risks vary greatly (e.g. [15–17]). Actors include individuals, social groups, government agencies, businesses, and non-governmental organizations. Social attitudes also shape how climate change impacts and consequences are valued, while shaping perceptions of their likelihood. The way social groups evaluate risks has cognitive, behavioral, and institutional dimensions. These flow from pre-existing and potentially diverse preferences, norms and values, as well as the *construction* of risks in public discourse in the media and other social arenas [16,18–20,21••,22•]. Thus, risks have two dimensions — the first is material and the second is socially constructed and culturally defined [6,22]. The same event characteristics and probabilities may appear very risky and intolerable for one group and as tolerable and manageable by another. Such differences also exist within groups. Across a population of actors, there will be a range of attitudes and responses with respect to the acceptability or tolerability of risks [23]. Applying a risk-based approach to adaptation acknowledges these differences of perception of risks, as well as differences in exposures, vulnerabilities, and modes of risk governance [19,21••,24,25].

Building on Klinke and Renn's work on risk governance [6,26,27] (Renn 2008:149), we recognize that an actor's appraisal of risk to a valued objective will place it into one of three main categories of response or adaptation. The categories have different implications for social responses and governance of risks. These categories may also be applied to climate adaptation in the following way:

- ***Acceptable risks*** are risks deemed so low that additional risk reduction efforts are not seen as necessary.
- ***Tolerable risks*** relate to activities seen as worth pursuing for their benefits, but where additional efforts (adaptations) are required for risk reduction within reasonable levels.
- ***Intolerable risks*** are those which exceed a socially negotiated norm (e.g. the availability of clean drinking water) or a value (e.g. continuity of a way of life) *despite adaptive action*.

Figure 1, adapted from Klinke and Renn [6,27], maps these categories of risk on a two dimensional space which focuses on the relationship between perceived probability and impacts where both the material and socially constructed dimensions of risks are combined, and highlights the often fuzzy or contested zones between classifications. Adaptation may be seen as action aimed at maintaining the position of a given valued objective (such as a technical norm of flood protection) within a tolerable area relative to this risk-space. In a dynamic or transitory risk context, such as climate change, the need for increased adaptive effort may mean that actors have increasing difficulty in achieving all of their pre-existing objectives. At the limit of an actor's capacity to secure a particular valued objective through adaptive effort, the perception of risks switches from tolerable to intolerable. As we have argued, both the valued objective and the point at which this objective is deemed to be exposed to intolerable risk will be socially and institutionally defined.

Limits to adaptation and transformative adaptation

The analysis of adaptation limits and their relationship to adaptation goals is a relatively recent development, yet one that emerges from earlier research about adaptive capacity [28–30]. Concepts such as tipping points and key

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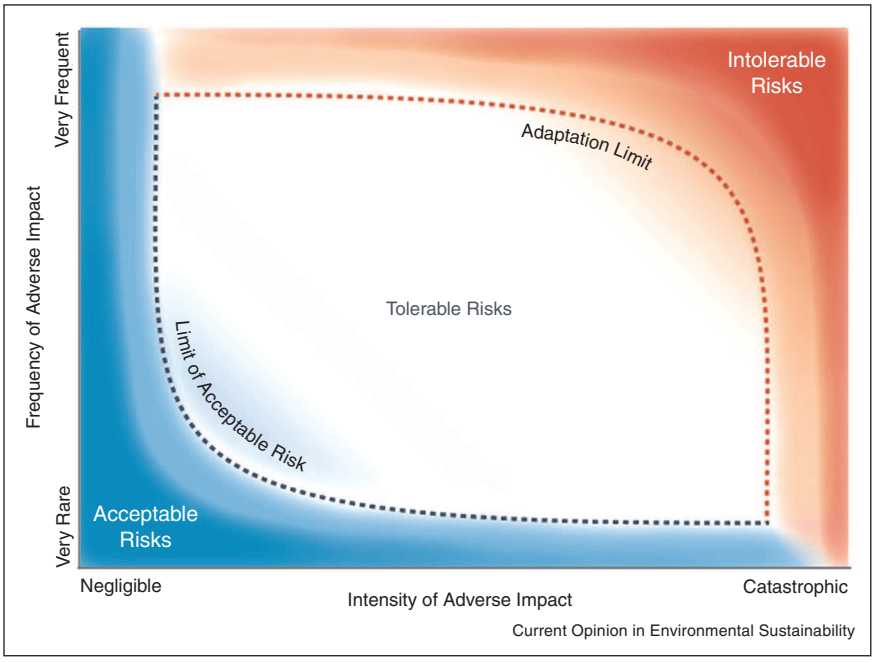
Figure 1



Acceptable, tolerable and intolerable risks ([32••] after [26,27]). Risks that cannot be managed to remain within a tolerable level exceed the limit to adaptation and become intolerable. The shading around the limits indicates that actors' views of what is acceptable, tolerable or intolerable risk may vary.

vulnerabilities imply that climate change impacts may overwhelm society's capacity to respond to avoid significant harm, but the linkage between biophysical changes and social responses has been left open [4,31]. There is also considerable ambiguity about definitions. Terms such as thresholds, barriers, and constraints are sometimes used as synonyms and sometimes given separate meanings. As Dow *et al.* [32••] observe, adaptation barriers and constraints represent obstacles to the implementation and planning of adaptation that can *in principle* be overcome. For example, resources may be transferred across scales from larger to smaller actors. In contrast, an adaptation limit implies a goal that cannot be realized. Adaptation is recognized to be a continuous process, but there may be limits to what objectives can be achieved with the capacity available to an actor. While the discussion of limits to adaptation in social systems is relatively new, the role of values in defining such limits is by now well-established [7,9••].

As the risks associated with climate change increase, actors may identify a threshold beyond which adaptations cannot hold risks to valued objectives within a tolerable range. Absent new adaptation options or resources, an adaptation limit represents a threshold of adaptive effort beyond which an actor must either live with intolerable risk of losses, revise attitudes about what is a valued objective, or change behavior radically to avoid the intolerable risk of loss. These actions will certainly be influenced by the objective and the type of loss. This approach acknowledges that, by some standards, there are actors who currently live in circumstances of intolerable risk to valued objectives.

While the realization that actors lack sufficient capacity (financial, social, political, technological, or cultural) to achieve their objectives indicates there are limits to adaptation, encountering such limits is not the end of the adaptation process. The emerging literature on transformational adaptation addresses this issue by highlighting that incremental changes may be insufficient to meet adaptation goals (e.g. [10••,33,34••]). Therefore, transformational changes may be required to facilitate continued adaptation in the face of adaptation limits. Kates *et al.* [34••] describe three classes of adaptation as transformational: those that are adopted at a greater scale or intensity; those that are truly new to a region or resource system; and those that transform places and shift locations. The authors argue that transformational adaptation would be a response to high vulnerability to climate change and its impacts. For instance, low-lying islands facing moderate sea-level rise under current conditions already face significant outmigration and may experience transformative change with severe or abrupt climate changes [34••].

As a further illustration, Kates *et al.* [34••] report that increased riverine and coastal erosion, driven in part by

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climate change, is threatening 26 Alaskan villages and motivating planning for relocation. From the perspective of adaptation limits [35], resettlement would indicate the lack of practicable or affordable adaptation options to secure a valued objective (living in a particular place with cultural significance). From a transformational adaptation perspective, such relocation may be seen as a positive choice for change. While relocation may include the experience of losses (e.g. [36]), the new circumstances may bring improvements in welfare. For instance, a new settlement may offer better educational or health service amenities. This is a subtle but important difference of emphasis, and in practical cases it may be hard to draw the distinction between an overall experience of loss and an experience of benefit, and it is possible that they will occur together. Differences in perspective and experience of changes may result in governance challenges. Leading up to 2009, 3 of the 4 communities seeking to move all at once (rather than piecemeal) due to an imminent threat posed by coastal erosion were making slow progress as, ''According to officials from these three villages, reaching consensus to relocate has been difficult. None of the decisions to relocate have been unanimous, . . ., with some residents preferring alternative locations, preferring different solutions, or preferring to remain in place.'' [37]. Marshall *et al.* [38] report that amongst peanut farmers faced with drought in Queensland attachment to place may also act as a barrier to transformative adaptation through discouraging translocation to another region. Hence, just as the objectives of adaptation and the definition of risk is socially constructed, so too is the capacity and willingness of actors to pursue transformative adaptive responses.

An actor-centered, risk-based approach to adaptation limits

Developing a robust, theoretically informed conceptual framework for adaptation limits is urgent given the persistent obstacles to achieving significant greenhouse gas mitigation, which increase the likelihood of large-scale climate changes and irreversible consequences [38]. Understanding whether valued objectives may face intolerable risks requires an understanding of actors' capacities to adapt. In seeking to better integrate risk-based approaches to adaptation and adaptation limits, we derive the following definition of limits to climate change adaptation.

Adaptation Limit: The point at which an actor's objectives cannot be secured from intolerable risks through adaptive actions.

This definition has two important elements that frame limits to adaptation in terms of risks to objectives valued by actors. First, it puts a focus on actors' perspectives, which could include a wide range of valued objectives, including, for instance, access to safe drinking water or protection from a vector-borne disease. Second, it highlights the concept of intolerable risk. Renn [6] observes that drawing the lines between intolerable and tolerable risks, and acceptable and tolerable risks are among the most difficult tasks for risk governance. What is intolerable is actor-specific and related to material characteristics of the risk and individually shaped and culturally shaped perceptions of that risk. And yet, these judgments are made at all levels of society [21••]. The risk framings and evaluations are currently negotiated through a wide variety of processes from individual and household decisions to public participation meetings, regulatory hearings, legislative action, and court proceedings [21••].

We illustrate our concept of adaptation limits with an example of potential limits to the cultivation of a staple crop in south Asia. Rice pollination and flowering has a threshold temperature of 26°C (at night), with a 10% decline in yield for every additional 1°C. Research indicates an absolute limit to pollination at 32–35°C [39]. With warming in South Asia, such conditions are projected to increase in future [40]. For the purpose of providing a plausible example, at the level of rice farmers the valued objective is the capacity to cultivate rice for consumption and for sale. At the level of a country like Thailand, the objective is the capacity to cultivate rice to secure food security and as an important export product. The intolerable risks would be the loss of farmer livelihoods and the security of supply of this staple crop. In this case, the inability to breed rice varieties that pollinate with night-time temperatures above the 32–35°C range [39] and the current absence of other practicable adaptation options to overcome this limit (such as protection of rice fields from ambient temperatures), threatens important objectives of farmers and Thailand as a whole. Under these circumstances, the future probability of rice harvests failures may increase along with related economic, social, and cultural impacts. These impacts would create the conditions under which farmers and policymakers would need to consider alternative crops, alternative locations for rice production, or alternative livelihoods. Such a change would impose economic losses on farmers, consumers, and export-related interests and could entail adjusting food preferences. The rice pollination example is represented in Figure 2.

In defining an adaptation limit, an important concern relates to the nature, probability, and scale of losses experienced at this limit. Losses may be tangible or intangible; physical, cultural or economic. Moreover, these will typically be large and potentially catastrophic for the actor concerned. At lower levels, these would count as tolerable (residual) damages after adaptation [41]. In many situations, adaptation to maintain risk at a tolerable level may entail some residual risk. In such cases, the losses may also be viewed as tolerable (e.g. the deductible on an insurance policy). An adaptation limit

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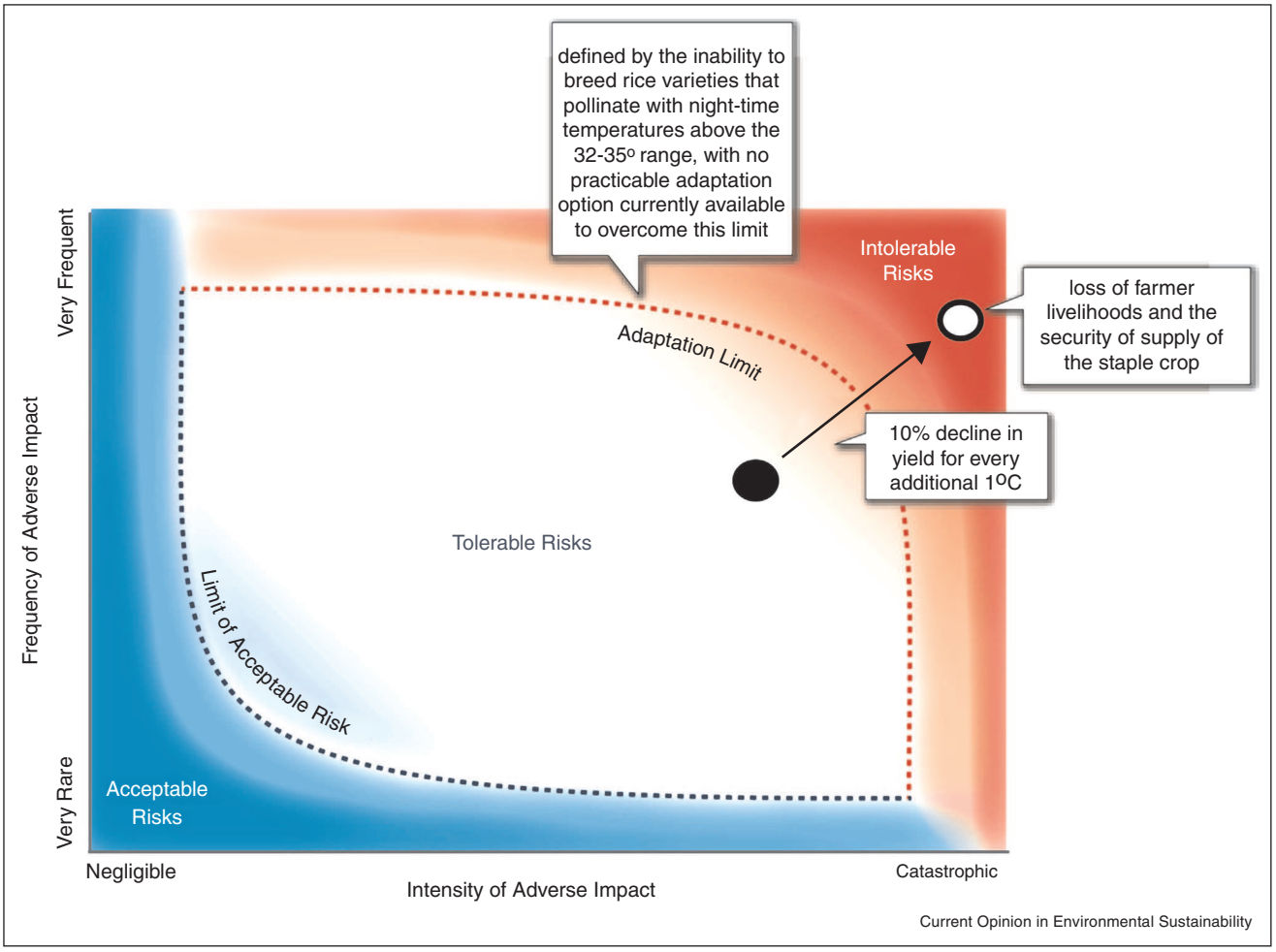
Figure 2



An adaptation limit to rice cultivation leading to loss of livelihoods and security of supply (based on [32••] after [26,27]).

represents a threshold beyond which risks and losses rise in an unmediated way to intolerable levels for the actor concerned. When a limit is reached, no practicable adaptation options are available, or an unacceptable measure of adaptive effort would be required to secure valued objectives. Therefore, a limit is a point when: either an intolerable risk to valued objectives must be accepted; the objective itself must be relinquished; or some transformation must take place to avoid intolerable risk. In the rice example, these three options would mean: the acceptance of a high probability of crop failure by farmers; a switch to an alternative crop like soybean or maize, or a displacement of rice cultivation to other regions.

The integration of risk into the framing of limits also adds a dynamism previously lacking. Adaptation limits have been framed as static or immutable thresholds [7]. For example, biophysical tipping points, which have been invoked as examples of adaptation limits, are assumed to represent critical thresholds beyond which attempts at societal adaptation will be overwhelmed [31]. We believe such biophysical limits to adaptation need to be integrated into a socio-ecological context. As we have argued, societal values and perceptions influence the definition of what is an intolerable risk and, by extension, what is an adaptation limit. Since values and perceptions change, so adaptation limits may also shift.

One implication of this dynamic view is that limits can change over time, and may therefore be mutable. Adger *et al.* ([7]:338) observe that "...limits to adaptation are mutable, subjective and socially constructed." Not only are the valued objectives being secured through adaptation socially constructed, but so are the perceptions of risks that threaten those values. What is valued and the capacity to secure valued objectives may change over time [22•]. Significant influences on social values are cultural change and changes in economic welfare and

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the interactions between them (e.g. [42]). Growing wealth will tend to generate more resources to devote to adaptation and to manage risks, while cultural change may generate new expectations about what are tolerable or intolerable risks. For instance, in many countries regulated standards for the management of environmental risks have been tightened over time as tolerance of risks has declined and the capacity to address them has grown. The capacity to address risks may also change as a result of technological change, or innovations in governance that emerge over time through investments in research and development, and institutional change. For instance, to return to the rice example, it may be expected that investments in developing heat-tolerant varieties will some day be successful and that pollination temperature limits are shifted upwards. For all these reasons, some limits as they are experienced in the present-day may change in the future, or what we term 'soft' limits. However, not all limits are liable to be mutable as a result of cultural, social, and economic change and innovation. We term these 'hard' limits. For example, it is unlikely that a certain probability of death will be considered tolerable under any circumstances. Likewise, it is unclear that some vulnerable coasts can be defended against sea-level rise, no matter what welfare growth, institutional changes or technological innovations emerge.

Conclusions: limits to adaptation and risk governance

On the basis of a broad set of literatures, we have developed an actor-centered, risk-based approach to understanding limits to adaptation to climate change risks [32••]. We define adaptation limits as the point at which, despite adaptive action, an actor can no longer secure valued objectives from intolerable risk. Developing a well-founded concept of adaptation limits is important because of the widely held assumption that the capacity to adapt in society and biophysical systems will not be infinite. This approach to adaptation limits can be applied to the full range of climate-related risks as they affect existing social values and objectives. A risk-based approach also points to a central policy challenge at all levels — that of defining the point at which climate-related risks to valued objectives become intolerable, acknowledging that this point will vary between actors and may be mutable over time as knowledge and technology develops, or as attitudes to risk evolve.

Adaptation limits will bring either increasing and serious losses, the abandonment of valued objectives or transformational behavior, such as resettlement, that result in a redistribution of risks and benefits to actors. In peripheral regions such as the Arctic, vulnerable coasts in South Asia or in mountainous regions of the world, we can already see limits to adaptation being reached. As climate change intensifies and accelerates, limits and associated disputes among actors over what are tolerable or intolerable risks and how to address the options once a limit is reached can be expected in a growing range of sectors, communities and places. These disputes are likely to place pressure on existing governance activities, such as policy development, which reflect objectives, attributes, norms and standards of individual and collective interests. Private and public institutions and resources will be called on to provide and secure values and objectives at risk, or to respond to losses. Intolerable risks to values and objectives mark a threshold; a point at which, for some actors, public–private resources and governance processes can no longer secure things they value. This may happen for conventional reasons including 'policy failure' in the sense of a policy not being effective, or due to a conscious decision to relinquish a particular social objective relative to another.

Inevitably, questions about risks to social objectives lead to distributional questions (who gets to keep things of value to them?) and associated governance challenges. Values and objectives may be *common* and shared between many actors (such as the desire for protection against the risk of wildfire), or they may be *private* to certain actors (such as the desire to live in a community threatened by coastal erosion). Even the small set of examples discussed here illustrates that expensive, time-consuming, politically charged social conflicts are likely as increasing numbers of actors begin to reach limits in their capacity to adapt to climate variability and change, and face the prospect of escalating losses, radically changed behavior, and migration. Improved understanding of what risks are held to be acceptable, tolerable, or intolerable, and where climate change may be pushing actors to adaptation limits, will be important for anticipating the types of governance processes needed to address these challenges and debates.

Acknowledgements

We would like to acknowledge valuable discussions with Mozaharul Alam, Habiba Gitay, Richard Klein, Guy Midgley, Rebecca Shaw, James Thurlow, and other generous colleagues from IPCC AR5 Working Group 2 who took time to listen and comment on this approach. Frans Berkhout would also like to acknowledge support of the European Commission-funded RESPONSES project in conducting this research. The shortcomings remain our responsibility.

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This paper argues that the magnitude of climate change vulnerability and risk may, in some instances, exceed the capacity of actors to adjust incrementally to manage the associated risks. As a consequence, transformational adaptations may be necessary. However, such transformational change may be difficult to implement due to uncertainty, high transaction costs, and institutional path dependence.

Please cite this article in press as: Dow K, et al.: Limits to adaptation to climate change: a risk approach, Curr Opin Environ Sustain (2013), http://dx.doi.org/10.1016/j.cosust.2013.07.005

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Please cite this article in press as: Dow K, et al.: Limits to adaptation to climate change: a risk approach, Curr Opin Environ Sustain (2013), http://dx.doi.org/10.1016/j.cosust.2013.07.005