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ORIGINAL PAPER

A preliminary discussion on the opportunities and challenges of linking climate change adaptation with disaster risk reduction

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Abstract Managing the risks of extreme events such as natural disasters to advance climate change adaptation (CCA) has been a global focus. However, a critical challenge in supporting CCA is to improve its linkage with disaster risk reduction (DRR). Based on discussions on similarities and differences between CCA and DRR concerning their spatial–temporal scales, main focuses, preferred research approaches and methodologies, etc., this paper tentatively put forward an analytical framework of "6W" for linking DRR with CCA. This framework presented preliminary answers to a series of fundamental questions, such as "What is adaptation with respect to disaster risk?" "Why adaptation is needed?" "Who adapt to what?" "How to adapt?" "What are the possible principles to assess the adaptation effect?" To bridge the research gaps between CCA and DRR, it is imperative to associate the adaptation actions with both near-term disaster risk and long-term climate change and formulate adaptation strategies at various spatial–temporal scales by embracing uncertainty in a changing climate.

Keywords Climate change adaptation · Disaster risk reduction · A "6W" framework · Challenges and opportunities · Sustainable development

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1 Introduction

Globally, with increasing trend of extreme events and climate-induced disasters over past decades, research on disaster risk reduction (DRR) in the context of climate change has gained more and more attentions. The notion of managing the risks of extreme events and disasters to advance climate change adaptation (CCA) was highlighted in latest IPCC special report (IPCC 2012). Continuous publications from the United Nations International Strategy for Disaster Reduction emphasized the notion of adaptation to climate change by reducing disaster risk (UNISDR 2009, 2010). Also, a core science project of Integrated Risk Governance under International Human Dimensions Program on Global Environmental Change (IHDP-IRG) was initiated (Jaeger and Shi 2008; Shi et al. 2010) for promoting integrated research on disaster risk in a changing world.

Along with growing attentions to both CCA and DRR among experts, policy makers, and practitioners, it is becoming clear that neither DRR nor CCA is about addressing disasters or climate change alone, but rather about confronting the societal context in which these changes are occurring (Adger et al. 2003). On the one hand, climate change is expected to increase the frequency and magnitude of many types of extreme events, including floods, droughts, tropical cyclones, and wildfires (IPCC 2001; Trenberth 2012). On the other hand, while the adverse impacts of climate change on society may increase disaster risk, disasters themselves may also erode environmental and social resilience, thus increase vulnerability to climate change (O'Brien et al. 2008). In particular, under a deep uncertainty owing to climate change, it is neither possible nor necessary to control all disaster risks (Han 2011). Adaptation has been one of the central means for sustainable DRR. Therefore, there are growing calls for a common framework to bring together the actions of adaptation to both near-term disasters and long-term climate change.

The main objective of this paper is to discuss the linkages and differences between CCA and DRR, as well as the opportunities and challenges to integrate them, in order to facilitate the mission of "managing the risks of extreme events and disasters to advance CCA" in the latest 2012 IPCC Special Report. Following a brief overview on the basic concept of adaptation, we discuss the dissimilarities and communalities between CCA and DRR in Sect. 3. An analytical framework is put forward in Sect. 4, and the key challenges of linking CCA with DRR are discussed.

2 A brief overview on the definition of adaptation

Adaptation, originally a biology or ecology term, is mainly adopted by biological and social–cultural researchers in the past. It means that human behaviors deviate from their original state in response to a pressure or driving effect (Winterhalder 1980). Actually, adaptation to environmental variability and change had been a focus for anthropologists since the first decade of twentieth century (Denevan 1983). In general, adaptation refers to the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities (IPCC 2012).

Despite previous diversified understandings on the definitions of adaptation, adjustment to change is one of the key elements with respect to adaptation (Young et al. 2005). An obvious divergence among these definitions is, "Should all kinds of adjustments be defined as adaptations (Smith 1996) or just a certain scope of them?" Within a coupled social–ecological system (Holling 1973, 1996), adaptation means the process, action, or ability

(Adger et al. 2005; Gallopin 2006) for an individual or a system to improve their inherent genetic or behavioral characteristics in order to better adapt to change.

Adaptation includes both moderating harm and exploiting beneficial opportunities (UNISDR 2009). The goal of adaptation aims not only to minimize the adverse effects, but to maximize its potential opportunities. It puts emphasis on the notion of "instead of trying to control changes, society needs to learn to live more compatible with the natural occurrence of disasters" (White 1974; Burton et al. 1978) and enhancing the resilience of a social–ecological system to uncertainty and surprise (Folke 2006). In recent decades, with climate-induced natural disasters increased remarkably, more and more researchers adopted the concept of adaptation in their disaster risk researches (Wisner et al. 2004; Birkmann 2006; Cutter et al. 2008). Adaptation to disaster risk is becoming one of the focuses also in disaster risk management.

3 Climate change adaptation and disaster risk reduction

Climate change adaptation is fundamentally related to managing climate-related risks (e.g., droughts and hurricanes). Strengthening CCA through effective DRR has been recognized as a new research interest in the fields of both climate change and disaster risk science. Particularly in the past decades, when humankinds try to tackle the challenge of managing the risks of extreme events and disasters under a deep uncertainty, their attitudes to climate change and related disaster risks have been evolved from "prevention and control" to "mitigation" (IPCC 2001, 2007), then gradually to "adaptation and transformation" (IPCC 2012; O'Brien 2012). Adaptation to disaster risk in a changing climate has been a global challenge and a key scientific focus within the framework of sustainability science (Turner et al. 2007; Kates 2011). Under such circumstances, this section attempts to perform a discussion on the relationship between CCA and DRR by considering their space–time scales, main focuses, and preferences for research approaches (Fig. 1).

3.1 Main differences between CCA and DRR

In temporal scale, despite the fact that disasters are often classified as suddenly happened ones with limited timescales (e.g., earthquake) and long-lasting ones with creeping features (e.g., drought), they refer primarily to relatively short-time events compared with the long timescale of climate change (Fig. 1). DRR is often event related and therefore rather short term in its interventions and procedures, while CCA strategies require long-term perspectives that go far beyond any political election period (Birkmann and von Teichman 2010). In terms of the spatial scale, climate change issues have, up to now, been analyzed primarily on a global scale, whereas disasters have been studied in the respective regions and localities where they occur (local/microscale) (Birkmann and von Teichman 2010). Accordingly, climate scientists have mostly paid attention to global models and global trends, whereas DRR researchers focus primarily on local vulnerabilities (Cutter et al. 2008) and risks of specific areas and certain groups of people.

Although climate change is expected to increase the frequency and magnitude of some climate extremes, e.g., it may cause more frequent wildfires and longer periods of drought in some regions, it will also bring some benefits and opportunities. For example, (a) an arctic that is ice free in summer would allow for new shipping lanes and open the possibility of oil and gas extraction (Olivier and Greenstone 2007); (b) diseases and deaths due to some cold weather might go down (O'Brien et al. 2008); and (c) in some regions,

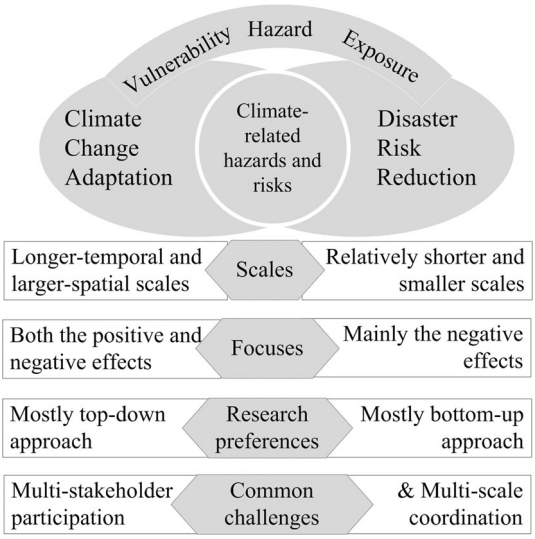

Fig. 1 A framework of comparing climate change adaptation with disaster risk reduction

climate change induced higher rainfall could open up new and profitable agriculture opportunities (Marshall et al. 2009). Therefore, climate change is just like a double-edged sword, which means that both the negative effects and the positive opportunities (Fig. 1) should be taken into account when addressing adaptation strategies. In contrast, DRR in most cases just pays attention to mitigating the negative impacts of disastrous events, including climate-induced extremes and nonclimatic events such as earthquake.

In addition, in contrast to the potential large-scale impacts of climate change, disasters occur first at the local level and affect local people (IPCC 2012). Therefore, DRR pays much attention to community-based approaches and bottom-up participation, whereas CCA emerged largely from top-down-driven policies that were initially disconnected to local communities (Mercer 2010). As a result, in terms of research approaches, previous studies on CCA have tended to give priority to a top-down approach (IPCC 2007) and attached importance to large-scale climate simulations and projections (Fig. 1). But, DRR pays much attention to bottom-up approach and local countermeasures. There is no doubt that the top-down approach is very important to identify the probable negative effects of future climate change, particularly in the global level. However, it cannot usually reveal and distinguish the underlying vulnerability of bottom victims (Pelling 2003), with the result that the most vulnerable people and regions are often excluded from decision-making and from access to entitlements. Thus, linking CCA and DRR requires the effective combination of top-down and bottom-up approaches on which the two communities primarily focus.

3.2 Opportunities for linking CCA with DRR

While their scope and specific interests may differ, CCA and DRR have similar goals in light of seeking to build resilience and adaptive capacity in the face of hazards. There are generally three basic components in the fields of both CCA and DRR, namely hazard, exposure, and vulnerability (Fig. 1). They both focus on reducing people's exposure and vulnerability to hazards by improving approaches to anticipate, resist, cope with, and recover from the negative impacts. In addition to the common climate-related hazards such

as droughts and hurricanes, reducing exposure and vulnerability of a socioeconomic system to external pressures is a priority for both CCA and DRR.

Climate change adaptation and disaster risk reduction can be mutually supplemented in many ways. On the one hand, implementation of policies and programs regarding DRR may limit the impacts of climate-related hazards and directly support adaptation to climate change. In addition, CCA is more inclined to adopt top-down approaches supposing that policies are directly translated into actions on the ground, whose effectiveness is often confined. Yet, DRR offers opportunities for carrying out bottom-up adaptation strategies of both present climate variability and future climate extremes. In this respect, DRR could promote early adaptation to climate risks and impacts (Shi et al. 2012), especially in addressing local policy to ongoing and upcoming climate change. On the other hand, adaptation to climate change will allow a system to mitigate the disaster risk by reducing its social vulnerability (Brooks 2003; O'Brien et al. 2004), thus to support DRR. At the local level, communities can seize on the window of opportunity created by climate-induced shocks to generate sustained social–ecological improvement (McSweeney and Coomes 2011), so that the potential disaster risk may be reduced. What is more, it is increasingly recognized that CCA and DRR must be the integral components of regional development planning to maintain sustainability.

4 An analytical framework for framing disaster risk adaptation in the context of climate change

Linking CCA with DRR is one of the crucial steps to achieve sustainable development in the near future. However, since past adaptation research has primarily paid attention to global change issues (Mastrandrea et al. 2010; O'Brien 2012), there is still not a reasonable conceptual framework for framing the issues of adapting to disaster risk in a changing climate, so as to bring together the actions of adaptation to both near-term disasters and long-term climate change. For this purpose, Schipper and Pelling (2006) attempted to employ a framework to integrating CCA and disaster risk management into socioeconomic development. Nevertheless, the proposed framework has focused largely on the policy dimension approaches that clearly cannot provide a systematic scheme targeting disaster reduction and climate-related adaptation. In addition, a latest IPCC report also put forward a framework to summarize the possible adaptation and disaster risk management approaches in a changing climate (IPCC 2012). Although this report proposed a wide range of adaptation strategies and approaches that may reduce the risks of climate extremes and disasters, it has largely stayed on the strategic and macrolevels. More explicit frameworks are required to transfer the theoretical arguments into some operational instructions.

In an attempt to address the key modules of climate-related adaptation, Smit et al. (2000) argued that a framework for systematically defining adaptation should be based on three questions: (a) Adaptation to what? (b) Who or what adapts? (c) How does adaptation occur? In recent years, however, with the extreme climate events and its attendant natural disasters dramatically increased, the previous climate adaptation-oriented framework cannot completely address the new proposal of "managing the risks of extreme events and disasters to advance CCA" (IPCC 2012). In other words, the past suggested adaptation framework should be updated and enriched in view of both the linkages and differences between CCA and DRR. Therefore, drawing inspirations from the above three basic questions and by considering the characteristics of disaster risk, this paper explores a

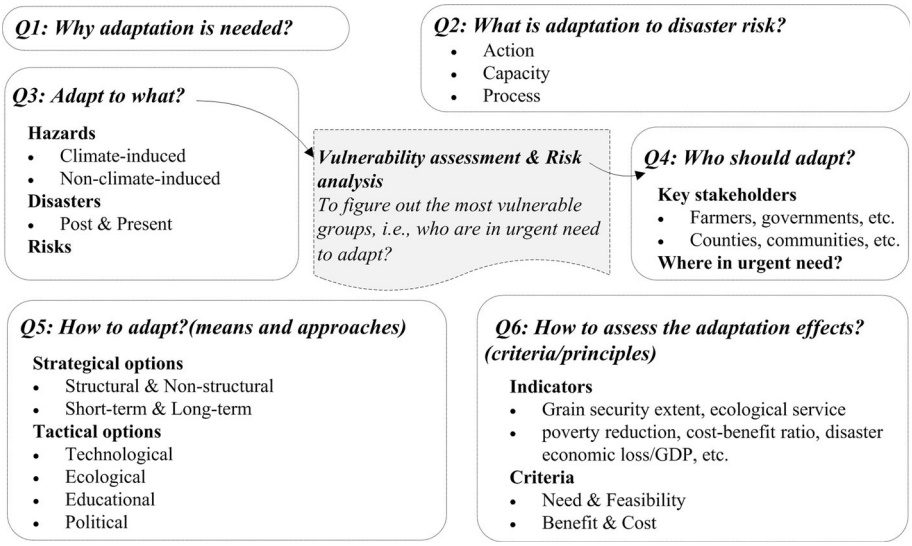

Fig. 2 An analytical framework of "6W" for framing disaster risk adaptation in the context of climate change (we call it "6W" because there is a character "W" in each of the above six questions regarding why, what, who, and how)

tentative analytical framework called "6W" (Fig. 2) to framing disaster risk adaptation in the context of climate change.

4.1 Why adaptation is needed for natural disaster risk?

Natural disaster, by its very nature, is not just a natural phenomenon (Birkmann 2006). Obviously, it is the social vulnerability and absence of effective adaptation that transform a hazard to a disaster or even a catastrophe (Smit and Wandel 2006). As early as the late 1940s, Gilbert F. White, a distinguished pioneer in natural disaster research, had been argued that instead of trying to control nature, society needs to learn to live more compatible with the natural occurrence of hazards (White 1974, 1986). An adaptive strategy for managing disaster risk may require human not by aiming for full prevention and control but by adjusting our behaviors, and to live with disaster risk for sustainable development.

4.2 What is adaptation to disaster risk?

As is similar to CCA, we define adaptation to disaster risk as the adjustments (both short term and long term) within social–ecological systems in response to actual hazards or expected risks and their impacts. Adaptation can be a process, an ability, or an action (Fig. 2), and it can be quantified as adaptability (or adaptive capacity) that could be improved through social learning. Adaptation will allow a system to reduce the risk associated with these hazards by reducing its vulnerability (Young et al. 2005). Adaptive capacity of a human system represents the potential of the system to reduce its social vulnerability, therefore to minimize the risk associated with a certain hazard. One of the essences for disaster risk adaptation is to moderate potential damages and to benefit from opportunities through a series of self-adjustments.

4.3 Adapt to what?

The external stress to social–ecological systems can be a hazard, an ongoing disaster, or a potential risk in the future (Fig. 2). The hazards may be climate-induced extremes (e.g., droughts and hurricanes) and also may not be climate-induced events such as earthquakes. Of course, learning from the past and present disasters could facilitate a better preparation for the next one. Meanwhile, an effective adaptation should attach more attention to potential disaster risks.

4.4 Who should adapt?

This question can be interpreted as to address the key stakeholders and priorities for adaptation (Fig. 2). Objective vulnerability assessment and risk analysis are needed to address the most vulnerable groups (Pelling 2003), more specifically, to figure out who are in urgent need to adapt. The participants of adaptation to disaster risk can be farmers, the local and central governments, or other stakeholders. Also, it is essential to determine which country, region, or community should be taken as a priority for implementing adaptation actions to disaster risk.

4.5 How to adapt?

The adaptation approaches can be classified as the strategic level and the tactical level (Fig. 2). Strategic adaptation options can be structural and nonstructural, short term, or long term. For example, adaptation strategies to floods include both temporary evacuation and long-term land-use planning, and necessary migration for DRR. Specific adaptation measures consist of technological (e.g., sprinkling or drip irrigation, soil and water conservation), ecological (e.g., introduction of antidrought crops, and land-use planning), educational (e.g., training and information sharing), political (e.g., formulating emergency plan, legislation, and political framing), and so forth.

4.6 What are the possible principles or criteria to assess the effectiveness of adaptation?

Some quantitative indicators could be employed for assessing the adaptive effects to disaster risk (Fig. 2), such as the "extent of grain security" in agricultural sector, "quality of ecological service" in mitigating environmental hazards, "poverty reduction effects" or simply "disaster economic loss/GDP," and more broadly the "sustainability index" to address DRR within socioeconomic development. Four criteria can be used in combination with qualitatively rank adaptive options for prioritization purposes (Marshall et al. 2009): need (extent of necessity), feasibility (whether it is easy to intervention), benefit (economic, ecological, or social interests), and cost (of affordability). Among all the suggested criteria, the cost-effectiveness should be highlighted because any adaptation action is related to a trade-off between maintaining economic development and mitigating accompanied disaster risks. Furthermore, the assessment of adaptation effects to disaster risk should be a dynamic process. A suitable adaptation mode in the past may not necessarily fit to the current disaster features. Likewise, a presently sound adaptive option would not be appropriate for the future risk scenarios.

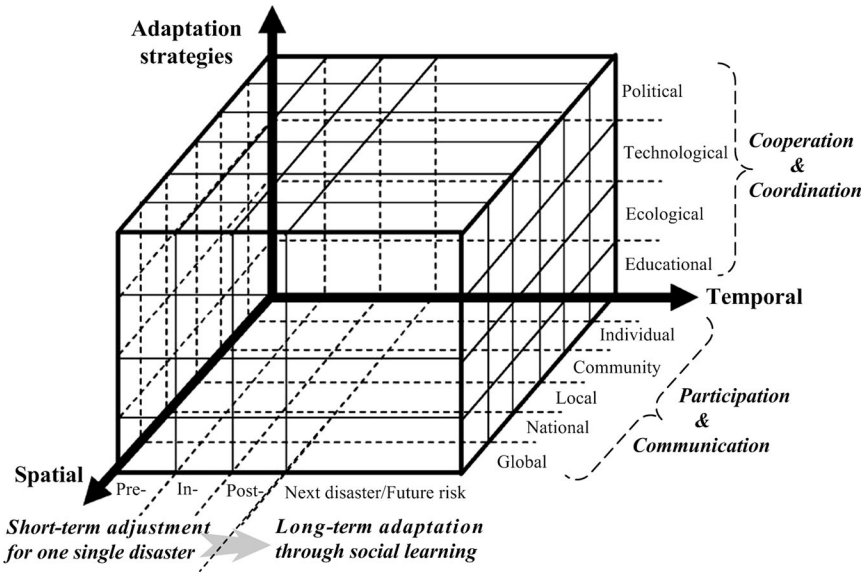

Fig. 3 A three-dimensional model to address the challenges of adaptation to climate change and related disaster risks

5 Challenges of adaptation to climate change and related disaster risk

We employ a three-dimensional model to address the main challenges of adaptation to climate change and its attendant disaster risk (Fig. 3). One of the key challenges we faced is the complexity of space–time dimensions when addressing adaptation strategies, given that there are increasing needs to building adaptation strategies for both near-term disaster risk and long-term climate change.

The temporal dimension of challenge consists of the short-term adjustments before, during, and after a disaster, and the long-term adaptation strategy for future risk and climatic uncertainty (Fig. 3). By addressing both present and future goals, it assists decision-makers to strategically deal with disaster risk and climate uncertainty by taking reasonable actions at different developing stages. The spatial dimension of adaptation depends on who perform the adaptation actions. Relevant participants include an individual, a local community, a certain nation, or even an international intervention (Fig. 3). Given different participants at different scales usually own diverse purposes, multiscale participation and communication is the key to achieve effective adaptation among various spatial scales. Also, assessing criteria to adaptation effects should be scale differential. That is to say, which region is better adapted to climate change or disaster risk than the others depends largely on its spatial locality, giving rise to a challenge for conducting a scientific vulnerability assessment and risk analysis under a deep uncertainty. Besides, adaptation strategies including educational, ecological, technological, and political should be given an integral consideration. A sound adaptation needs to strike a balance between different adaptive approaches.

It is believed that an effective adaptation needs the involvement of a wide range of stakeholders such as scientists, policy makers, private firms, NGOs, media, educators, and the public (IPCC 2012). Therefore, one of the most difficult tasks for an effective

adaptation is to coordinate various interests of different stakeholders. For example, when talking about adaptation to agricultural drought, the interests of the farmers, the local, and central governments are often inconsistent. The farmers may primarily focus on the drought impacts on their livelihoods and economic incomes, while the local government might be concerned with the drought-induced ecological problems such as land degradation and water shortage, but the central government usually pays more attention to the yield losses caused by drought and the regional grain security. The disaccord interests among different participants in most cases make it difficult to reach a consensus on specific adaptation measures. In view of this challenge, a mechanism of multistakeholder participation and communication for decision-making is the key to a reasonable adaptive solution.

6 Discussion and conclusions

Linking CCA with DRR should be one of the crucial steps to achieve an efficient adaptation to climate change in the near future. However, in the past decades, the academic communities of DRR and CCA have been mostly working in isolation (Thomalla et al. 2006), which resulted in an outcome that both communities failed to reduce the social vulnerability to climate-related hazards. It is therefore of great significance to develop a cross-community dialogue and learning process. There can be a win–win solution for integrating the strategies of CCA and DRR. DRR could promote early adaptation to climate risks and impacts, especially at the local level. Correspondingly, adaptation to climate change will allow a system to mitigate the disaster risk by reducing its social vulnerability. In the long run, if CCA policies are to be efficient, they must build on existing DRR efforts. And, if DRR approaches are to be sustainable, they should take into account the impact of climate change.

Although one of the collective tasks for CCA and DRR is to reduce the risk of human society to external stresses, to bridge the research gaps between them is not an easy task. The first difficulty is to address the key stakeholders and priorities for climate-related adaptation in order to guarantee social equality (i.e., to appropriately answer the question of "Who should adapt and be taken as a priority?" in the "6W" framework). Objective vulnerability assessment and risk analysis are essential to figure out the most vulnerable groups for prioritized adaptation. Second, in order to address another key question of "How to adapt?" in the "6W" framework, tangible cooperation and coordination are needed to integrate the political, technological, ecological, and educational adaptation strategies together. Third, adaptation actions require a series of trade-offs, including coordination between short-term economic benefit and long-term investment in DRR and CCA for sustainable development.

In terms of bridging the gap between science and decision-making (Kasperson 2010; Mastrandrea et al. 2010), it is essential to construct a mutual dialogue and learning mechanism among different academic communities (e.g., current diverse research focuses on vulnerability, resilience, CCA, and disaster risk mitigation) to facilitate the mission of "adaptation to climate change by reducing disaster risks" in the IPCC reports. In particular, CCA and DRR experts, policy makers, and practitioners should communicate and collaborate with each other effectively to ensure an integrated risk management and sustainable development within the broader context of climate change.

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