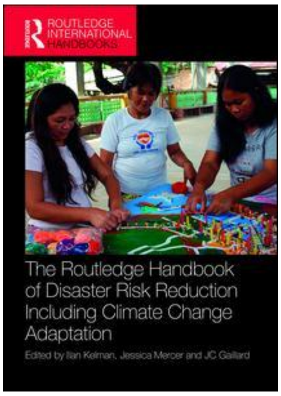

The Routledge Handbook of Disaster Risk Reduction Including Climate Change Adaptation

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Disaster Risk Reduction: A Critical Approach

Publication details
https://www.routledgehandbooks.com/doi/10.4324/9781315684260.ch3
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Published online on: 27 Apr 2017

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DISASTER RISK REDUCTION: A CRITICAL APPROACH

Rajarshi DasGupta and Rajib Shaw

Introduction

From ancient civilizations to modern 'technological-driven' societies, human history has shaped and been constantly reshaped by natural hazards. One of the several hypotheses behind the collapse of the great Indus Valley Civilization during 1800–1700 bc, is of a series of droughts followed by an eastward shift of the monsoon. Consequently, historians and palaeo-climatologists argued that the vibrant ancient cities of Mohenjo-Daro and Harappa came to a complete halt due to extreme paucity of rain that virtually forced its dwellers to abandon these ancient cities. Likewise, a series of natural hazards – e.g., earthquakes and drought – between 1225 bc and 1177 bc led to the downfall of ancient societies, including the great Egyptian civilizations, heralding the beginning of the 'dark age' (Cline 2014). As people and communities continue to deal with a plethora of natural hazards, they also learn from, and adapt to, these experiences. This collective experience largely indicates, that, at least to some extent, the adverse consequences of natural hazards can be avoided through careful and timely planning; and that the solution lies in either containing the forces of nature, which in itself leads to problems and often transference of the hazard elsewhere, or by altering our own behaviour and addressing vulnerability. This has led to significant societal transformation over the years and as a result, the concept of 'Disaster Risk Reduction' (DRR) emerged and received recognition.

The Evolution of 'Disaster Risk Reduction' and Links with Climate Change Adaptation

According to the English dictionary, the word 'disaster' can be traced to its origin from a sixteenth-century Italian term 'disastro', which generally refers to an 'ill-starred event' [dis- (expressing negation) + astro 'star' (from Latin *astrum*)]. The word has been retained in the English vocabulary ever since and has been indiscriminately used to denote a wide sense of purpose ranging from the occurrences of large natural hazards (e.g., earthquakes, typhoons, etc.), undesirable physical events (e.g., power cuts, disease outbreaks, etc.) to social and political blunders. Nevertheless, in a traditional sense, the word 'disaster' is closely connected with the word 'accident', since any event that led to loss of life and/or property was either referred to as a 'disaster' or an 'accident'. Since the English dictionary definitions of these two words are quite close, it was necessary to set up the criteria by which we may distinguish a physical or human caused incident as 'disaster'.

Over the last three decades, there have been several attempts to draw a distinctive definition of 'disaster' and to set up the criteria by which an incident can be termed as a 'disaster'. For example, a definition of disaster, posed by the International Worker's Party and cited in Rutherford and Boer (1983, p. 10), described disasters as a 'destructive event, which, relative to the resources available, causes many casualties, usually occurring within a short period of time'. This definition implied three boundary conditions to separate disasters from accidents: (a) 'resource availability', (b) 'many casualties' and (c) 'short period of time'. De Boer (1990) later justified that if a sudden shock could be managed by utilizing own resources and minimizing casualties, this could be referred to as an 'accident', rather than a 'disaster'. For instance, they argued that 'even a serious explosion or fire need not be a disaster in the presence of adequate facilities for rescue and treatment' (De Boer 1990, p. 592).

Nevertheless, the general assumption even during the early sixties was that natural hazards were more or less an 'Act of God', and that they could potentially trigger an extreme event that would require humanitarian assistance to recover. During the late sixties, this assumption changed and DRR strategies such as sea walls, dams etc., were used to 'tame the force of nature'. This changed again in the late seventies and early eighties when the 'vulnerability' approach to disasters gained momentum by rejecting the assumption that disasters are an outcome of a natural hazard(s) alone and outlining links with the surrounding social environment (see Box 3.1). The realization of the fact that disasters result from complex interactions between human and natural systems also led to the hypothesis, that even with a high probability of natural hazards occurring, not all communities remain equally prone to damage. Consequently, it was identified, that disasters are functions of 'Hazard' and 'Vulnerability' (Disaster Risk (R) = Hazard (H) × Vulnerability (V)), and in particular, since 'Hazards' are generally considered as sudden shock events (although also slow-onset, e.g., droughts), it is rather imperative to manage the 'vulnerability' component, which is inclusive of several complex and interlinked social, human, economic, environmental and physical variables (Blaikie *et al.* 1994). For example, amongst other things, 'vulnerability' may include poor design and construction of buildings, social isolation, economic incapacity, inadequate protection of assets, lack of public information and awareness, limited official recognition of risks and preparedness measures, and disregard for wise environmental management (UNISDR 2009). For instance, taking into consideration solely the earthquake of the Great East Japan Earthquake and Tsunami that occurred in 2011, then this cannot be referred to as a 'disaster' in the true sense of the term due to Japan's excellence in earthquake engineering (Kelman and Glantz 2015). However, sadly the tsunami generated by the earthquake did cause a disaster, demonstrating failure to reduce vulnerability and prevent the tsunami from becoming a disaster (Kelman and Glantz 2015).

Box 3.1 Disaster Risk Reduction – A Brief History

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DRR alongside other related terms including emergency assistance, disaster response and relief, humanitarian assistance, emergency management, disaster mitigation and prevention, and disaster risk management were originally incorporated under the umbrella term 'Disaster Management' (UNISDR 2004). The past forty years have seen DRR disassociate itself from 'disaster management', moving away from the technocratic paradigm that viewed natural hazards as something to contain and control through engineering structures and sophisticated monitoring technology. The technocratic paradigm primarily focused upon the hazard and single, event-based scenarios under command-and-control mechanisms with established hierarchical relationships. However, despite use of such technology the impact of natural hazards upon populations worldwide has only continued to increase. That is due to the over-focus upon the 'naturalness' of disaster events when it is the interaction between a hazard(s) and humans that could potentially result in a disaster. This has denied the wider historical and social dimensions of the hazard (Bankoff 2001). That contributed to the development of the alternative paradigm that viewed disasters as products of vulnerability; i.e., socio-economic and political in origin rather than natural (Hewitt 1983; Torry 1978, 1979; Blaikie *et al.* 1994). The alternative paradigm focuses largely on vulnerability and risk issues, and responds to dynamic and multi-risk scenarios utilising multiple actors and adapting to differing situations. Hence, DRR in its present day form is now seen as 'the systematic development and application of policies, strategies and practices to minimise vulnerabilities, hazards and the unfolding of disaster impacts throughout a society, in the broad context of sustainable development' (UNISDR 2004, p. 3).

In recent disaster literature, the above relationship has been modified further with the incorporation of two terms, 'exposure' and 'coping capacity'. Within hazard research, 'exposure' is largely defined by the entities exposed and prone to hazard impact(s). In particular, 'exposure' is defined mostly in temporal and spatial terms. For example, according to the World Risk Report (2011), exposure is related to the potential average number of people who are exposed to earthquakes, storms, droughts and floods, etc. On the contrary, societal dynamics may change the vulnerability of particular groups or individuals over time (Shaw *et al.* 2010). For instance, experiential learning from mega disasters such as the Great East Japan Earthquake and Tsunami in 2011 essentially indicates that a high awareness of communities and effective, efficient resource management also leads to substantial reduction of disaster risks and effective post-disaster humanitarian response. For the same reason, the consequences of a powerful earthquake in Japan and Nepal are distinctly different. These factors, collectively known as 'coping capacity', are the intrinsic properties of a community that can substantially reduce disaster impacts. According to these conceptual amendments, 'Disaster Risk' is now represented as:

$$\text{Disaster Risk (R)} = \frac{\text{Hazard (H)} \times \text{Exposure (E)} \times \text{Vulnerability (V)}}{\text{Coping Capacity (C)}}$$

Many researchers, predominantly over the last decade, have attempted to clarify this equation. In particular, it has become essential to look further into the variables of Vulnerability (V), Exposure (E) and Coping Capacity (C), in order to implement strategies to reduce vulnerability and exposure, and increase coping capacity with respect to particular individuals, communities and regions. A host of theoretical research has been conducted to identify the key factors that affect these three components. For example, Blaikie *et al.* (1994) categorized the component vulnerability into root causes (such as limited access to power and resources, poverty, health, education or lack of human development) and dynamic pressures (such as lack of local institutions, population growth, etc.). The root causes outlined by Blaikie *et al.* (1994) are linked to a lack of human development that potentially leads to high vulnerability levels. For instance, poverty, in all its forms and means, is the single largest denominator of high vulnerability to natural hazards irrespective of geographic locations. In addition, given anticipated changes in the climate, potentially more and more people will live under new or escalated risk of natural hazards and extreme weather events. As in the case of natural hazards, natural hazard drivers including climate change will hit the poor hardest. However, observed and predicted consequences of climate change are highly uncertain and are essentially not linear. For instance, changes in rainfall may lead to flood in one area and drought in another, and may be of benefit to some whilst of negative consequence to others.

Since the publication of the third Intergovernmental Panel on Climate Change (IPCC) assessment report, there has been strong consensus among the international community that climate change will bring certain adverse consequences despite our best possible mitigation measures. In response to that, governments need to prepare systematic plans to adapt to these changes. At a global policy level the domain of Climate Change Adaptation (CCA) received recognition during the Conference of the Parties (COP) 11 in 2000 for the United Nations Framework Convention for Climate Change (UNFCCC) in Nairobi, emerging alongside the earlier advocated Green House Gas (GHG) mitigation strategies. In particular, the lack of international commitment observed in the Kyoto protocol led less wealthy countries to shift more towards adaptation rather than mitigation. Hence, significant attention was given to CCA issues in successive COPs, particularly in the 'Bali Road Map (2007)' as well as during COP 15 in Copenhagen (2009).

CCA, therefore, has become a developmental priority over the last decade or so. However, the main question is whether CCA is a standalone policy entity or whether it should be embedded within the scope of DRR, given the many overlaps that exist both in policy and in practice. The IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) (IPCC 2012) recommends addressing both the issues in coherence rather than in isolation. However, critiques of this report outline the clear tension within it between authors who place CCA within wider contexts and those that prefer to view climate change in isolation as an aside from other disaster and vulnerability concerns (Kelman *et al.* 2015). The emphasis of the report as per the mandate of the IPCC is still to advance CCA (IPCC 2012) without due consideration to wider disaster and vulnerability concerns.

Others argue that the domain of DRR essentially relies on experiential learning, while CCA largely revolves around the meticulous identification of possible future scenarios (Shaw *et al.* 2010). However, DRR by definition and by nature must look to the future as well as the past to determine the most cost effective DRR strategies. It therefore remains imperative to identify the overlap areas between these two domains, particularly from a practitioner perspective. The following section attempts to narrate the commonalities between CCA and DRR and argues how best the ideas of CCA can be embedded within the scope of DRR.

Commonalities and Coherences between Disaster Risk Reduction and Climate Change Adaptation

It is imperative to understand that both CCA and DRR, alongside the Sustainable Development Goals (SDGs), are essentially developmental issues with many of the targets highly overlapping. For example, the eradication of poverty, which is one of the SDGs, will essentially contribute to achieving the target of reducing disaster including climate risk as well. Moreover, in reality, it is extremely difficult to segregate the issues of climate change as a hazard driver and hazards, since communities do not feel the impact of natural hazards and climate change separately. Hence, practitioners and policy planners need to consider both these issues coherently. On the contrary, CCA itself is often considered as a subset of DRR from an academic perspective, with DRR being a subset of development. As has been mentioned, historically human civilizations have adapted to large-scale natural hazards and gained experiential learning. This, in turn, has helped them to prepare for the next big event – e.g., the Moken indigenous people of Thailand and Jarawa tribes of India's Andaman and Nicobar islands managed to anticipate the Indian Ocean Tsunami during 2004. The powerful ability to interpret the signs and symbols of nature is a great example of the exceptional ability of these indigenous people, who, over thousands of years, have learnt to live by the sea and adapt to change experienced.

CCA has the potential to substantially reduce many of the adverse impacts of climate change, thereby reducing future 'vulnerability'. Similarly to DRR, CCA also requires substantial access to information, mobilization, active management of resources and knowledge sharing. Hence, principal CCA activities are identified as similar to DRR approaches such as vulnerability reduction, strengthening coping capacity and reducing direct exposure through long-term, self-sustaining community based or ecosystem based measures (see below). Additionally, implementation of CCA and DRR approaches starts with a similar process through building a common understanding, undertaking a structured review of potential strategies and cost–benefit analysis (Shaw *et al.* 2010). Further, it is often argued that for both CCA and DRR, active community involvement remains imperative for successful implementation of DRR including CCA policies and action plans.

Institutionalization of Disaster Risk Reduction

Although the components of disaster risk (hazard, vulnerability, exposure and coping capacity) have been identified since the early seventies, in many cases national governments have continued to focus on relief centric approaches. That is, given the difficulties in tackling the many facets of vulnerability. The thematic identity of DRR, however, received its desired attention when the United Nations declared the 1990s as the 'International Decade for Natural Disaster Reduction' (IDNDR). Consequently, the 'Yokohama Strategy and Plan for Action' were adopted at the first United Nations World Conference on Disaster Risk Reduction (WCDR) in 1994 as the first international policy guidelines for DRR. On the termination of IDNDR, the United Nations General Assembly established the secretariat of the United Nations International Strategy for Disaster Risk Reduction (UNISDR) to facilitate implementation of the International Strategy for Disaster Reduction (ISDR), a successor mechanism of the IDNDR. The second WCDR held in Kobe, Japan, in 2005, was attended by 168 member countries and resulted in the 'Hyogo Framework for Action (HFA), 2005–2015: Building the Resilience of Nations and Communities to Disasters' (UNISDR 2005). This was the first milestone of the institutionalization of DRR and considered as a monumental shift. Through five sets of priorities, the concepts of DRR, as put forth in the HFA, reflected a stronger focus upon risk preparedness and prevention, as compared with response and recovery.

The HFA resulted in some policy alteration at national government level, with many countries coming up with Disaster Management Acts, policies and long-term risk reduction plans. Yet, despite a significant mobilization of resources and development of new capacities for DRR at the national government level, contemporary progress reviews (e.g., Global Assessment Report on Disaster Risk Reduction (UNISDR 2015) and the Global Network of Civil Society Organisations for Disaster Reduction (GNDR) Frontline Report (2013)), largely indicated the exclusion of local governments and communities in local level DRR policy framing and implementation. In addition, little has been done to reduce underlying risks, such as environmental degradation, contributing to vulnerability.

The HFA framework was replaced by the Sendai Framework for Disaster Risk Reduction (SFDRR), which was put into place following the third WCDR held in Sendai City, Japan, in 2015. The SFDRR has an operational period of 15 years (2015–2030) and outlines its goals in four priorities: 1) Understanding disaster risk; 2) Strengthening Disaster Risk Governance; 3) Investing in Disaster Risk Reduction for Resilience; and 4) Enhancing disaster preparedness for effective response, and to build back better in recovery, rehabilitation and reconstruction. Although it is too early to measure the utility and effectiveness of the SFDRR, many argue that the absence of baselines and lack of distinctive responsibilities and quantitative targets are the major drawbacks of the SFDRR (Chatterjee *et al.* 2015).

The year 2015 was equally important from the climate change perspective, particularly due to the adoption of the Paris Agreement of UNFCCC, which sets forth new targets for greenhouse gas emissions mitigation, adaptation and finance starting in the year 2020. The agreement is now open for signature and as of 2 August 2016, there are 179 signatories. Similar to the SFDRR, the Paris Agreement has also been criticized due to a lack of binding targets. However, beside the traditional GHG mitigation, one of the thrust areas of the Paris agreement is enforcing CCA and adaptation financing for resilient societies. It is, however, imperative to mention that within the scope of CCA (as formulated in Paris agreement) and DRR (as formulated in SFDRR), a whole lot of similarities and broad overlap exist between the targets. In particular, both these documents revolve around enhancing community resilience against short-, medium- and long-term hazards by incorporating effective adaptations through proper institutionalization and global partnership.

Contemporary Approaches for Disaster Risk Reduction and its Synergies in Climate Change Adaptation

The key issues for both DRR and CCA are to identify the approaches that can translate the theoretical notion and policies into appropriate risk reduction measures. In this section, we discuss the existing approaches of DRR that may also have simultaneous applications in CCA. Over the last two decades, especially since the adoption of HFA, several theoretical developments of specific DRR approaches have been formulated against a variety of physical and economic backgrounds. What is interesting to note, is that, compared with the traditional hard engineering based risk reduction approaches, which, at a point in time, were considered the only way to reduce the exposure of communities to specific hazards, several alternative approaches evolved to meet the objectives of controlling exposure, reducing vulnerability and enhancing coping capacities. These approaches remain equally applicable for a climate resilient society and form the very basis of long-term CCA planning.

Some of the well-researched approaches that have been applied include Community-based Disaster Risk Reduction (CBDRR), Ecosystem based Disaster Risk Reduction (Eco-DRR) and Restrictive Planning. Collectively known as 'Soft-approaches or No-Regrets approaches for Disaster Risk Reduction', these specifically aim to capitalize on existing human and natural resources for proactive risk reduction from hazards including hazard drivers such as climate change. These approaches, in many cases, are complementary to traditional hard engineering based DRR approaches, and often, based on the hazard profile and the community capacity, can be used in tandem. It is, however, imperative to understand the potential scope and opportunities of these specific approaches. Table 3.1 provides a summary of the contemporary approaches of DRR alongside their specific contribution to reducing vulnerability and exposure, and increasing coping capacities. The following section describes in short the specific applicability of these different approaches.

Table 3.1 Approaches for DRR

DRR Approaches	*Reducing Exposure*	*Reducing Vulnerability*	*Enhancing Coping Capacity*	*Applicability and Utility*
Engineering based disaster risk reduction	(Major Role) For example, sea dikes, earthquake resilient buildings, dams and reservoirs	(Semi-Major Role) Mainly reducing physical vulnerability	(Major Role) Advanced early warning, scientific modelling of risks	• Adequate financial capacity of the national and local government • In-depth understanding of hazards and uncertainty • Reliability
Community-based disaster risk reduction (CBDRR)	(Minor Role) Not directly related, however, better community understanding of risks leads to reduction of exposure; such as not settling by the sea etc.	(Major Role) Creating local assets and mutual understanding, enhances social capital	(Major Role) High disaster awareness, efficient evacuation, culture of preparedness	• Existence of weak local governments • Applicable in local risk management • Net social benefits with long-term sustainability
Ecosystem based disaster risk reduction (Eco-DRR)	(Major Role) For example, storm surge attenuation, soil accumulation, erosion control etc.	(Major Role) Asset creation in terms of livelihood and physical resources	(Minor Role) Creating environmental awareness for sustainable ecosystem management	• Low cost adaptive approach. • High utility in CCA • Generates net environmental benefits
Restrictive Planning	(Major Role) For example, planned retreat, coastal regulation zones	(Semi-Major Role) Mainly reducing physical vulnerability, however, may increase social vulnerability	(No Role)	• High relative cost • Requires proper legislation and policy reforms • May lack social acceptability

Engineering Based Disaster Risk Reduction Including Climate Change Adaptation

Having emerged during the 1960s, the traditional approaches for DRR have been, by and large, hard engineering approaches, which, to a significant extent, have been successful in reducing risk from natural hazards including climate-related hazards. For example, the extensive embankment network of the Netherlands serves as the most prominent illustration of this. This system of robust dikes with extensive mechanization has been tremendously effective in mitigating storms and surges. The system is constantly upgraded to meet changing exposures and anticipated impacts of climate change. However, as outlined in the introduction the implementation of engineering based approaches for DRR including CCA also comes with a negative side; e.g., encouraging people to build in flood plains or in areas that may possibly be inundated in the future or transference of the hazard elsewhere. For example, nearly 9,600 km of Japan's 35,000 km coastline are protected by sea dikes that are designed to protect the adjacent human habitation from the Level-1 Tsunami [according to Kaigan hou (Japanese Sea-Coastal Law of 1953, amended 1999), Level-1 Tsunami are the events that may occur once in a hundred years]. These hard engineering risk reduction measures demand major capital investments and recurring maintenance costs. Yet, these hard and strong coastal defence mechanisms have not always been as productive as planned, since the sea dikes only provided a false sense of security during the East Japan Earthquake and Tsunami in 2011. In addition, sea dikes are also considered to have negative environmental impacts, such as disruption of natural shoreline processes and destruction of shoreline habitats such as wetlands and intertidal beaches. Nevertheless, despite certain ambiguities, engineering solutions for DRR remain a trusted approach in many wealthier countries.

Community-based Disaster Risk Reduction (CBDRR)

CBDRR is defined as a process in which affected communities are at the centre of any risk reduction strategy. This is often referred to as a participatory and bottom-up process that is initiated, led and/or managed by the community itself (often with the assistance of outsiders such as NGOs) and is not a request/order from higher authorities. The principal arguments of this approach lie in the understanding of the fact that communities know their situation best and as such are best placed to initiate a process of identifying strategies to address their risk. In particular, CBDRR attempts to reduce the risk of disasters within a community, by focusing on the root causes of risks, addressing it through the most appropriate knowledge, whether this be local, internal knowledge or external knowledge and/or assistance – or, usually, a combination (see Box 3.2). This approach has been adopted in many countries within the last decade and has been one of the principal developmental doctrines since the adoption of the HFA. Although it still lacks legal recognition in many countries, international agencies, including UNISDR, strongly encourage active participation of communities in managing local disaster risks.

Box 3.2 Community-based Disaster Risk Reduction and External Vulnerabilities in Coastal Bangladesh

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[4] British Red Cross, Dhaka, Bangladesh
Based on Ahmed *et al.* (2016).

From 2013 to 2016, two Bangladeshi coastal communities in Patuakhali district, Nowapara and Pashurbunia, participated in the Vulnerability to Resilience (V2R) programme implemented by the Bangladesh Red Crescent through funding and technical support made available by the British Red Cross and Swedish Red Cross.

With special attention given to the poorest households, activities included cash-for-work for constructing and improving community access roads; cash for new livelihoods and livelihood diversification; building latrines and tube-wells for freshwater while providing hygiene advice; and providing safety equipment for fishers. Training was provided for business development, market access, community mapping, first aid, search and rescue, and early warning. Community members across socio-economic classes were engaged in CBDRR activities, whereas little occurred before, particularly through using sustainable livelihoods and livelihood diversification to implement DRR.

Just after V2R ended on 30 April 2016, Cyclone Ruanu made landfall on Bangladesh's south coast on 21 May 2016. The people in the V2R communities received warnings and evacuated, so no casualties were reported. They returned afterwards to find that many of the new initiatives had withstood the storm and subsequent flooding from a broken embankment. Their new freshwater supply and latrines continued to function. Livelihoods received little interruption, apart from agricultural fields being salinated by the storm surge, so many people switched to fishing while rehabilitating the land to continue cultivation. CBDRR succeeded by focusing on root causes of vulnerability through shoring up sustainable livelihoods and basic services.

A new seaport might be constructed nearby, meaning that the communities might experience forced eviction and major landscape changes which would significantly disrupt their livelihood patterns and undermine V2R's work. Although the people now have more skills and resources to address this challenge, CBDRR can be undermined by external creators of vulnerability and disaster risk.

Ecosystem-based Disaster Risk Reduction (Eco-DRR)

One of the much referred to international policy documents of the last decade was the Millennium Ecosystem Assessment (2005), which reemphasized the need for harvesting the unbounded relations between humans and nature, especially by promoting the concept of 'Ecosystem Services'. With poor environmental practices, many of the world's ecosystems remain critically degraded. This, in turn, increases risk, not only by increasing exposure to natural hazards, but also by enhancing the potential vulnerability, especially in terms of livelihoods and access to resources. For example, many communities in less wealthy countries are directly dependent on ecosystem services for their livelihoods, and, therefore, remain particularly vulnerable to changes in environmental conditions (Renaud *et al.* 2013). Efficient management of ecosystems, that aims to revitalize or enhance ecosystem services, is an essential approach for DRR including CCA. The HFA also recognized environmental degradation as a major contributing factor for disaster risk (Doswald and Estrella 2015).

The synergies between sound ecosystem management and DRR including CCA have received wide recognition since the Indian Ocean Tsunami, as various reports and case studies of the potential wave attenuation capabilities of mangroves were referred to after the catastrophic tsunami (e.g., EJF 2006; Kathiresan and Rajendran 2005). This, in particular, renewed interest in ecosystems and their services in DRR, giving rise to a new concept of 'Ecosystem-based Disaster Risk Reduction' or Eco-DRR. The 'Eco-DRR' concept has received wide recognition since the United Nations Environment Programme (UNEP) adopted this concept as their doctrine for ecosystem conservation. In general, these approaches are hypothesized as low-cost, futuristic risk reduction approaches that are aimed at generating net social and ecological benefits.

For example, Hiraishi and Harada (2003), based on a theoretical study, suggested that a coastal forest of 30 trees per 100 m^2 in a 100-m wide belt may reduce the maximum tsunami flow pressure by more than 90 per cent. However, clearly this is not always the case and is dependent on many factors, not least the extent of the hazard(s) concerned. In monetary terms, Eco-DRR approaches are typically considered as highly cost-effective. For example, Gilman *et al.* (2008) outlined that the replacement cost of existing mangroves with rock walls in Malaysia has been estimated at USD 300,000 per km. Further, the cost of current mangrove restoration in Thailand is estimated as USD 946 per hectare, while the cost for protecting existing mangroves is capped to only USD 189 per hectare (Gilman *et al.* 2008). In comparison to engineered seawalls, this cost is negligible.

Restrictive Planning

Another approach for DRR including CCA largely revolves around the principles of restrictive planning. Evolved mostly in the early 1990s, restrictive planning largely attempts to reduce disaster risks by decreasing direct physical exposures, such as by demarking specific zones in coastal areas and planned retreats of human settlements from highly vulnerable and disaster prone areas. Collectively, known as 'soft' approaches for DRR including CCA, restrictive planning such as planned retreat / managed realignment of coastal zones under threat of rising sea levels provides a potential approach where building hard engineering structures is beyond the capacity of the governments (Abel *et al.* 2011). In addition, it also provides the space for ecological succession that is imperative to reduce the exposure further. In this process derelict lands are often left to natural regeneration of vegetation, such as mangroves in coastal areas. This then forms the basis of long-term risk reduction including the risks of hazard drivers such as climate change.

Conclusion and Way Forward

All the above-discussed DRR approaches, individually and collectively, remain imperative from the perspective of minimizing the risks of natural hazards that may intensify or diminish with climate change. Thus, they are imperative for CCA approaches also. As has been mentioned, governments and policy planners can choose one or a combination of approaches based on their understanding of risks as well as the social, economic and technical capacity of the concerned communities. This understanding of risk needs to be inclusive as well as futuristic to accommodate the probable uncertainties of climate change.

Nevertheless, it is imperative to recognize the underlying causes of disaster risks and a thematic assessment of the 'scale' and 'context' for policy planners needs to consider a specific DRR including CCA approach or a suitable combination. 'Scale' – i.e., the extent of coverage area – is among the basic requirements for adopting a specific DRR including CCA approach. For example, engineering based DRR including CCA may be applicable on a small scale or for a certain region, while restrictive planning such as planned retreat from susceptible coastlines can be advocated for at a national level. Similarly, the 'context', especially high or low technical and economic capacity of the government, also remains a major determinant for choosing a specific DRR including CCA approach. CBDRR has become overwhelmingly popular in less wealthy countries due to the lesser requirement for capital investments. Additionally, policy researchers have profoundly recommended this approach as being ameliorative for fostering planned and spontaneous adaptation to the adverse impacts of climate change. Similarly, Eco-DRR is considered as a potential alternative to engineered DRR in the backdrop of limited technical and economic capacity. These approaches not only have long-term sustainability, but also are often self-sustaining and cost effective for reducing disaster including climate change risk.

Decision-making for the appropriate combination of risk reduction approaches is not easy and must remain site specific. Local knowledge is an essential component that needs to be harnessed and integrated for drafting effective DRR including CCA strategies. A multitude of other factors such as economic and technical capacity, thematic understanding of risks, social acceptance (e.g., it is probably impossible to prohibit a fishing community from living near the coast), community participation and perception, and long-term environmental and social impacts are some of the key parameters that lead to effective decision-making in this regard. In particular, community-based and ecosystem-based approaches have high social return that will benefit even in the absence of major hazards. One of the substantial challenges for appropriate decision-making in combining DRR including CCA approaches is the lack of previous experience and shortage of case studies, which, largely, restricts evidence-based choices. These gaps will minimize over time as global communities, including governments and academia, put more emphasis on local and regional DRR including CCA through innovative, action-led, proactive risk reduction measures.

Another substantial problem in decision-making is that, despite the many similarities, the domains of CCA and DRR have not been integrated at international and national levels due to political and governance reasons. At the international level, the parallel existence of CCA and DRR forums and platforms working to achieve similar targets is, at times, highly confusing for practitioners. While these platforms are working separately on many similar issues, it remains imperative to merge and accomplish the common targets in order to simplify the complexities. Segregating CCA measures from DRR strategies is illogical and deceptive in many cases. A community-led sectoral approach, for example, improving livelihood resilience utilizing DRR including CCA strategies is perhaps a more cognitive risk reduction approach than segregated action planning for DRR or CCA.

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