Introducing Linkages Between Climate Change, Extreme Events, and Disaster Risk Reduction

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Abstract

Climate change has become an important factor for many environmental disasters in vulnerable communities and ecosystems. Poverty, poor education and health facilities and other aspects of human population in low and middle income countries have led to increased exposure and high levels of vulnerability and risk. Most of the deaths caused due to different disasters have occurred in developing countries. As a consequence, major efforts at the international level have been made to reduce the risks related to various disasters. The International Decade for Natural Disaster Reduction (1990–1999) was one of the important international initiatives followed by the International strategy for Disaster Reduction (1999), the Yokohama Strategy (1994), the Hyogo Framework for Action (2005), and most recently the Sendai Framework, the Paris Agreement, and the Sustainable Development Goals (all in 2015). Furthermore, the Intergovernmental Panel on Climate Change (IPCC) has played a fundamental role in assessing the state of knowledge in climate and impact science for almost 30 years. This introductory chapter summarizes the international initiatives in this field and thus prepares the ground for the following chapters which are introduced at the end of this chapter.

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Introduction

The Earth's climate has experienced unprecedented warming over the past few decades(IPCC 2012). The average global surface temperature has risen by 0.85 °C during the period of 1880–2012, and the last three decades (1983–2012) were the warmest 30 years over the last 1400 years in the northern hemisphere (IPCC 2013). As per climate model results, the global surface temperature is expected to further rise by 1–4 °C on the average by the end of this century relative to the period of 1986–2005, strongly depending on the greenhouse gas emission pathways (IPCC 2012). The changes in the climate systems have aggravated modifications in functioning of ecosystems (Schickhoff et al. 2016; Shrestha et al. 2012; Xu et al. 2009) and led to occurrence of many extreme events across the globe (IPCC 2014a, b; Vargas et al. 2017; Sorokin 2017). The frequency of high temperature events, warm days, and nights has increased, while low temperature events, cold days, and nights have declined across the globe (IPCC 2013). Extreme rainfall events (floods and droughts) have increased in many parts of the world (Goswami et al. 2006; IPCC 2013, 2014a, b; Schickhoff et al. 2016), while the number of rainy days has declined (Rani and Sreekesh 2017).

The model results suggest that due to future climatic warming, related extreme events will increase during this century. High temperature events are expected to increase, whereas the number of cold days and nights will decline (IPCC 2013). The frequency of heavy rainfall events is expected to increase, as well as wildfires due to increased evaporation, transpiration, and drought spells in future (IPCC 2012, 2013). As a result of temperature increase sea level will rise, which may at a later stage lead to global cooling as well (Sorokin and Mondello 2017). Besides extreme climate events, the major impacts of the climate change include changes in the microclimate and weather patterns (Praveen and Sreekesh 2017; Rani and Sreekesh 2017; Sorokin 2017; Degórska and Degórski 2017), worldwide glacier recessions (Bolch et al. 2012) and associated sea level rise (IPCC 2012) and coastal flooding (Chen et al. 2017), sedimentation in river basins (Ahmad and Das 2017), glacial lake outburst floods (Allen et al. 2016; Quincey et al. 2005; Huggel et al. 2002), changes in the vegetation patterns (Zolotov et al. 2017) and phenology (Kundu et al. 2017), agricultural yield (Milanova et al. 2017; Schick et al. 2017), food security (Beer 2017), and damage and loss to populations and economies (UNISDR 2008; Singh 2006; Mukwada and Manatsa 2017).

State of Disaster Impacts: Emerging Scenario

According to a UN-ESCAP Report (2015), a total of 11,985 natural disaster events were reported in the world during 1970–2014, of which floods and storms share about 64% and represent sharp increasing numbers in recent decades. However, the magnitude of changes in climatic extremes is not uniform across the globe, wherein some vulnerable ecosystems such as high altitude (mountains), high latitude, coastal regions, and developing regions such as Asia have observed more visible changes (IPCC 2014a, b; CRED-UNISDR 2015; Shrestha et al. 2012; Xu et al. 2009). The climatic extremes have repeatedly resulted in major disasters including heavy losses of infrastructure, economy, natural environment, and human populations (IPCC 2012), not only in the immediate areas but also affected downstream regions (Bisht et al. 2011; Evans and Clague 1994; Mal and Singh 2014). For instance, the Uttarakhand floods (2012, 2013), the Mumbai floods (2005), and the Kashmir floods (2014) in India, the heat waves of 2003 and 2006 in Europe, in 2017 in Delhi, the extreme winters of 2009–2010 in Mongolia, the European floods (2013), and many other such events caused unparalleled damage (IPCC 2012). Additionally, the droughts, heat, and cold waves and other extreme events do not only affect the human population but also ecosystems which in turn may result in negative effects on people due to shrinking provisions of ecosystem services (UNIDR 2009). These extreme events over the period of time have further exposed large populations to different levels of risks, especially in developing countries making them highly vulnerable to disasters (Singh 2000, 2006; UNISDR 2008). In some critical regions such as the Himalaya, hydro-climatic extreme events have been observed to increase over the past decades (Stäubli et al. 2017; Joshi and Kumar 2006; Goswami et al. 2006) with often major consequences for the vulnerable population and local economy.

Developing countries and poor people in high-income countries are disproportionately affected, mostly due to lower level of preparedness, high degree of exposure, and vulnerability (UNISDR 2008, 2009, 2015a; IPCC 2014a, b; Poterie and Baudoin 2015). Increasing economic and social inequalities, high population growth, and haphazard unplanned developmental activities, especially in developing countries, have further negatively influenced adaptive capacity and coping mechanisms of local peoples (UNISDR 2008, 2009). The economically and socially weaker sections in developing countries are specifically at higher risk (Poterie and Baudoin 2015). Significant economic inequalities can be understood from the fact that the lowermost half of the global population owns less than 1% of total global wealth (UNISDR 2015a).

According to the UN Global Assessment Report on Disaster Risk Reduction , more than 1.6 million people died due to different disasters worldwide during 1990–2013 (UNISDR 2015a), with more than 95% of the deaths worldwide during 1970–2008 from natural disasters occurred in developing countries (IPCC 2012). The economic losses from such disasters have been estimated to be about US$ 250 billion to US$ 300 billion/year since 1990s, and expected annual economic losses by 2030 are estimated at US$ 415 billion, of which US$ 314 billion will be only in built environment alone (UNISDR 2015a). Further, the mortality and loss of economies due to disasters are increasing in low-income countries (UNISDR 2015a; UNESCAP 2015). Therefore, in view of the fact that climate change and related extreme events will lead to increased future losses (IPCC 2012; UNISDR 2015a), it is imperative to combat climate-related disasters and reduce the inherent risks toward a safer world in a coordinated manner at international, regional, national, and local levels.

Contribution of Intergovernmental Panel on Climate Change (IPCC): A Climate Watch

The IPCC has been the most important scientific organization working since the late 1980s in the field of and at the interface of international climate science and policy. The IPCC so far published five assessments reports and several special reports dealing with the scientific basis, impacts, adaptation, vulnerability, and mitigation of climate change. Among the major special reports "Managing the risk of extreme events and disasters to advance climate change adaptation," popularly known as SREX 2012, is the most important contribution in the field of climate-related disasters in recent times. Specifically, the SREX 2012 deals with climate change and related extreme events, their impacts and mitigation strategies at international to local levels.

The review of the various assessments and special reports indicates that the scientific understanding of extreme events and related disasters has over the period evolved from the technical understandings of the climate science and its impacts in First Assessment Report, introduction of mitigation and adaptation in Second Assessment Report, vulnerability in the Third and Fourth Assessment Reports, and eventually a strong focus on the risk component in the Fifth Assessment Report. According to IPCC (2012, i.e., SREX 2012), DRR focuses on minimizing the exposure and vulnerability and enhancing resilience against the climatic extreme events. The SREX was instrumental in bringing together the disaster risk and the climate change communities, and an important result was the agreement on a comprehensive definition of disaster risk involving probability of hazard, and degree of exposure and vulnerability (IPCC 2012).

The Fifth Assessment Report of the IPCC (2014a, b) demonstrated the important nexus between climate change mitigation, risks, and adaptation. Mitigation has a decisive role in effectively limiting climate-related risks, in line with Article 2 of the UNFCCC, while adaptation is important to reduce risks to lower levels. This nexus implies that less effective climate change mitigation implies higher investments in adaptation to reduce risks to tolerable levels.

The exposure and vulnerability to disaster are ever changing with time and space and largely depend on socio-cultural-economic conditions of communities and environmental factors. The level of education, economic status, class hierarchy, age–sex structure, geographic location, etc., determine the level of vulnerability and exposure to disasters (Singh 2015; IPCC 2012, 2014a, b; Grover and Parthasarthy 2012), which further determines the extent of impact of climate change and extreme events (Mirand et al. 2017). Thus, it is important to take them into account for the DRR and strengthening of local adaptive capacities to counterforce the increasing levels of disaster risks due to the widely observed increasing exposure and vulnerability (IPCC 2012; UNISDR 2010).

Changing Perceptions of Disaster Risk Reduction

The mitigation of disasters is attempted through the disaster management cycle that has primarily three stages, namely, pre-, during, and post-disasters. Disaster mitigation, preparedness, relief, rehabilitation, risk reduction, and response are important components of disaster management cycle. Overtime, the stage to be focused has shifted depending upon the understanding of the concept of disasters.

The concept and idea of DRR and related notions have evolved over the years expending (Fig. 1) its horizon from disaster reduction in the early 1990s to coping capacities and relief interventions (response and recovery) in the early 2000s to risk reduction, preparedness, prevention, management, and adaptation to climate change by reducing the vulnerability and building resilience, involving more socio-economic-institutional components in recent times (Poterie and Baudoin 2015; Brieceno 2015a, b).

The discourse related to disasters at the international level began in 1989, when the United Nations declared 1990–1999 as the International Decade for Natural Disaster Reduction (IDNDR) in view of the increasing extreme events caused due to climatic and anthropogenic changes (Poterie and Baudoin 2015). Here, the focus was only on natural disasters. The IDNDR primarily focused on the reduction and prevention of the disasters itself, e.g., flood extents and associated damages were attempted to be reduced based on structural measures such as check dams, embankments, and other technological interventions. Research on disasters during the IDNDR therefore often had a more technological perspective and had limited focus on reduction of risks and exposure as important components and drivers of risk, and key aspects for managing disaster risk.[1,2]

The First World Conference on Natural Disaster Reduction held in Yokohama in 1994 adopted the landmark “Yokohama Strategy” and “Plan of Action for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation,” which reasserted the IDNDR’s focus (Poterie and Baudoin 2015). It urged upon

[1]http://www.unisdr.org/who-we-are/international-strategy-for-disaster-reduction. Accessed on June 1, 2017.
[2]http://www.eird.org/eng/revista/No15_99/pagina2.htm. Accessed on June 1, 2017.

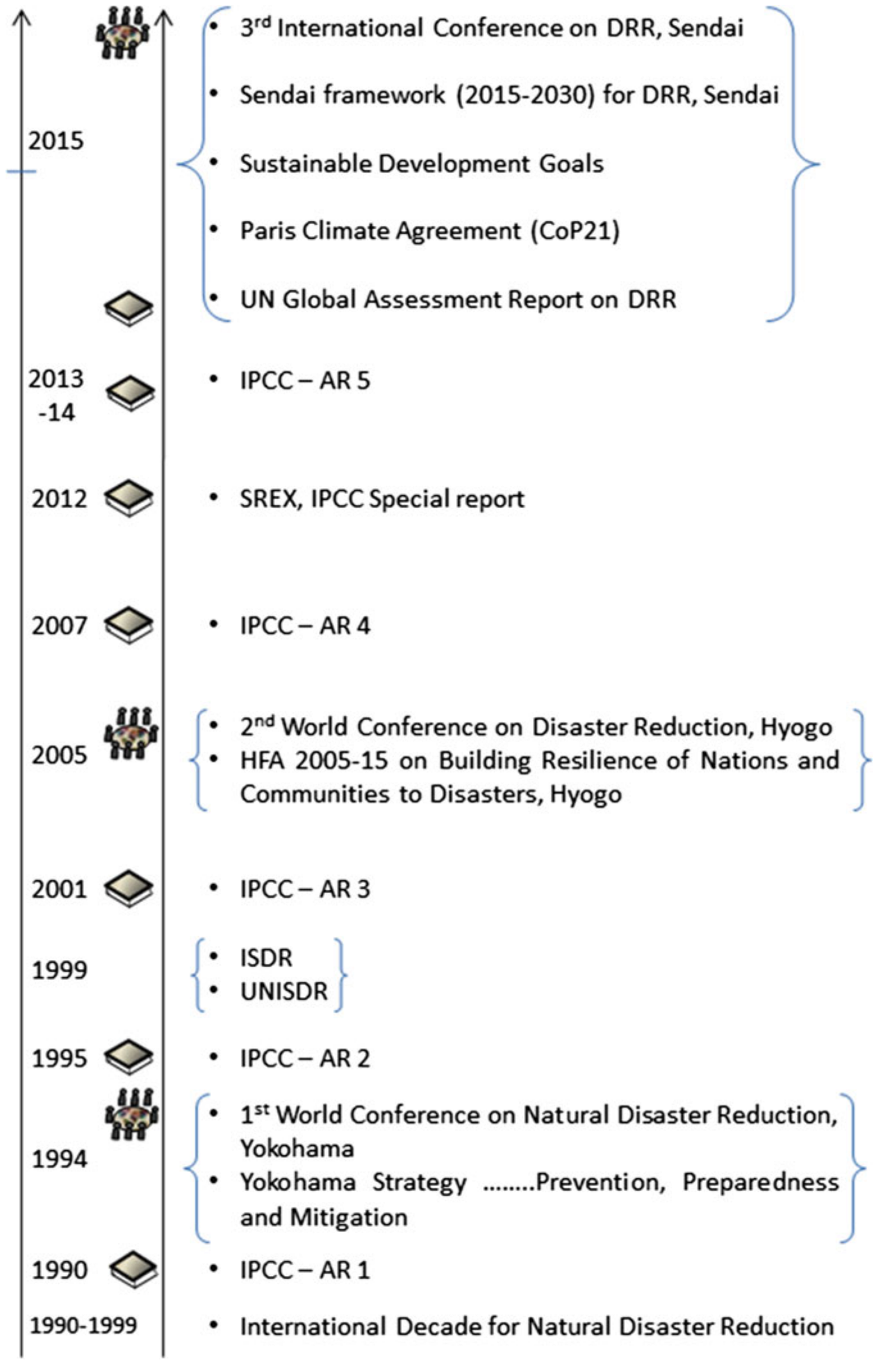

Fig. 1 Development of concept of DRR during last three decades

disaster prevention, preparedness, early warning, recovery, enhancement of local capacities, improvement in coping mechanisms, and integration into national policies to reduce the impact of disasters (UN 1994a, b). The recognition of traditional knowledge, practices, and values in addition to the local expertise was among the prime focus of the strategy (UN 1994a).

Later in 1999, the international efforts were further strengthened by launching the International Strategy for Disaster Reduction (ISDR). The ISDR was based on the experiences and lessons learned during the IDNDR (1990–1999) that the hazards and disasters are unavoidable and will affect the human society in future (see Footnote 1 and 2). Besides, there were some shortcomings and gaps that could not be properly considered during the IDNDR, which were also stressed upon in the Yokohama Strategy (1994). The report of 2nd World Conference on Disaster Reduction (2005a) underlined some major gaps in the Yokohama Strategy (1994) including "(1) disaster governance and policy framework, (2) identification of risk and its assessments and monitoring, (3) management of knowledge and disaster education, (4) preparedness for effective response and recover system, and (5) improvement in national and local capacities to build their resilience to ensure disaster risk reduction and sustainable development" (UNISDR 2005a, b).

Therefore, the prime focus of ISDR was to reduce the risks associated with the hazards and disasters. The scientific learning, the societal knowledge, and indigenous cultural practices were increasingly recognized to minimize and prevent the disasters (see Footnote 1 and 2). The broad vision of ISDR was to make human society more resilient to the hazards and risks by reducing their vulnerability to disasters (Poterie and Baudoin 2015). The ISDR further called for the integration of risk prevention strategies through involvement of authorities and local communities into the practice of sustainable development (see Footnote 1 and 2).

The ISDR program was adopted by the UN in 1999 and thereafter called United Nation International Strategy for Disaster Reduction (UNISDR). The UNISDR is responsible for the implementation of DRR programs and strategies among the UN member countries. The discussions at the 2nd World Conference on Disaster Reduction (2005) in Hyogo, Japan, further expanded the scope of DRR by involving the resilience component of communities to disasters. The conference adopted the "Hyogo Framework for Action (HFA) 2005–2015: Building the Resilience of Nations and Communities to Disasters," which was perhaps the most important document that popularized the DRR notion across the world (Poterie and Baudoin, 2015).

The main aim of the HFA 2005–2015 was to reduce disaster-induced losses of population, socio-economic, and environmental assets (Poterie and Baudoin 2015) by promoting an active role of local learning, resilience building, and climate adaptation through the integration of DRR into strategies and the planning process by 2015 (UNISDR 2005a, 2008). Therefore, five key areas of priority were identified, viz. (1) DRR as a priority in national policy, (2) identify, assess, and monitor disaster risk and enhance early warning, (3) use knowledge, innovation, and education to build a culture of safety and resilience at all levels, (4) reduce the underlying risk factors, and (5) strengthen disaster preparedness for effective response at all levels (UNISDR 2005a, b). However, community learning and experiences were not well recognized and promoted. The HFA 2005–2015 increased the focus on risk preparedness, prevention, and reduction of risk vulnerability in lieu of response and recover as stressed during the ISDR (Poterie and Baudoin 2015).

The year of 2015 was perhaps the most significant year in the discourse of DRR and international frameworks for sustainable development, since three important events, viz. the Sendai Framework for DRR 2015–2030 and the Sustainable Development Goals, both voluntary, and the legally binding treaty of the UNFCCC, i.e., Paris Agreement (CoP-21) took place this year (Poterie and Baudoin 2015; Kelman 2015).

The Sendai Framework for DRR 2015–2030, the successor of HFA: 2005–2015 (Poterie and Baudoin 2015; Kelman 2015), was discussed and adopted at the third International Conference on DRR at Sendai, Japan, in 2015 (UNISDR 2015b; Briceno 2015b). Over the period of nearly three decades, on account of global initiatives, the average number of disaster-related mortality (deaths per disaster) has slightly declined since 1970 (UNESCAP 2015). In many cases, it is observed that the hazards and extreme events are not necessarily leading to disasters (Kelman and Glantz 2015) as they are managed well through better coordination of early warning systems, preparedness, and disaster response. However, the number of affected people continued to rise over last 10 years, leaving over 1.4 million people injured and about 23 million homeless (UNISDR 2015b). Besides, the exposure and vulnerability levels of poor and dependent sections, especially in the developing countries have increased (Briceno 2015a). The Sendai Framework 2015–2030 witnessed a paradigm shift from HFA: 2005–2015, wherein the thrust now shifted to adaptation to climate change, increased resilience to present and future hazards, and management and mitigation of disaster risk (Poterie and Baudoin 2015). In addition to the natural hazards, the Sendai Framework focused on the human-made hazards, and risks related to techno-environment and biological hazards (UNISDR 2015b). Earlier, the disasters were considered purely natural phenomena, but by 2012 it was recognized that significant causes of disasters are anthropogenic in nature (IPCC 2012), e.g., floods are not just natural hydrological events but can be indirectly caused by anthropogenic activities such as large-scale deforestation, resulting in changes in local climates, altered runoff regimes, and eventually floods.

It was also realized during 2005–2015 that DRR can be further improved through governance involving various stakeholders from local to global levels, building resilience of local communities, better preparedness, and response mechanisms (Singh 2015). Besides, DRR is required to be more people-centric with involvement of governments with vulnerable groups, viz. woman, youth, poor, person with disability (UNISDR 2015b). Further the trans-boundary cooperation, local capacity building, technology transfer, and financial support were needed for better DRR process (Kelman 2015).

The Sendai Framework also focused on prospective risk management, reducing existing risks and compensatory risk management (UNISDR 2015a, b), which are also stressed in the Global Assessment Report on DRR (UNISDR 2015a). Therefore, the Sendai Framework prioritizes four key areas for action, i.e., (1) understanding disaster risk, (2) strengthening disaster risk governance to manage disaster risk, (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 (UNISDR 2015b). The fundamental aim of the Sendai Framework is to substantially reduce number of deaths and affected people, economic loss, infrastructure, and basic services by 2030 (Singh 2016; Poterie and Baudoin 2015). Besides, it also promotes the coordination and cooperation among its parties (member countries) for better DRR (UNISDR 2015a, b). DRR has now become an international strategy to spread awareness about causes, impacts, and reduction of impacts of disasters (Poterie and Baudoin 2015). However, Briceno (2015b) identifies some shortcomings in the Sendai Framework 2015–2030, viz. "prioritization in the implementation of recommendations of the Sendai Framework, quantified tasks, and implementation plan for the frameworks." There was more focus on science and technology and less on value of local knowledge, learning, and practices with respect to DRR (Poterie and Baudoin 2015). Kelman (2015) suggested that the "hazard part of disaster risk is overemphasized and to effectively combat DRR it could focus more on vulnerability and resilience to climate change." The DRR process was further strengthened through UNISDR Science and Technology Conference at Geneva during January 27–29, 2016. The conference focused on global partnerships, integrated linkages of exposure, vulnerability and risks, collection and use of data including the standards and innovative practices, knowledge hubs, gender inequality, supporting publishing practices, youth involvement, bioethics, and ethics of science and technology in DRR with active input from IAP (the Inter-academy Partnership)-Global Network of Science Academies (Dickinson and Murray 2016). IAP also organized General Assembly at Hermanus, South Africa with initiating a panel on science advice during emergency situations arising out of disasters. The DRR is further strengthened by constituting a working group of Experts on Science and Technology for DRR by IAP for bringing global issues to the attention of policy makers.

Emergence of SDGs for Global Sustainability

The Sustainable Development Goals (SDGs), also known as "Transforming our world: The 2030 Agenda for Sustainable Development" succeeded the Millennium Development Goals (MDGs). The MDGs indirectly aimed to confluence with the aims of the ISDR by eradication of poverty, education promotion, environmental stability etc[3]. The Sendai Framework and the SDGs were approved by the UN in 2015. The SDG framework is closely linked to and inherently supports DRR efforts. The SDGs can play an important role to develop resilience toward disaster exposure, vulnerability, and risk reduction (UN 2015). The UNISDR (2015a) asserts that "development cannot be sustainable unless the risk of disasters is reduced". In total, 17 goals and 169 targets were identified with the broader objectives to end poverty, access to resources, lowering the inequalities, ecological balance with inter- and intra-generational equity, and combat climate change impacts (UN 2015). The SDGs closely align with DRR, which involves understanding the scientific bases of a variety of natural and socio-economic processes, capacity building of local authorities, communities, and other stakeholders for DRR.

The SDG 13, i.e., "Climate Action" particularly deals with international efforts to minimize the impacts of climate change by taking steps such as promotion of renewable energy and reduction of emission of greenhouse gases[4]. The SDG Climate Action was included in the SDGs with the view that climate change presently is one of the biggest challenges for our society. The SDG on climate action has identified some important targets to be fulfilled by 2030 that includes improving the understanding of disasters, enhancing the level of education, awareness, stakeholders and institutional capacity, adaptation, resilience, mitigation, risk reduction of hydro-climatic disasters across the world and integration of climate change into the national and local level policies (UN 2015).

The Paris Climate Agreement for Our Common Future

The Paris Agreement, product of and adopted at the Conference of Parties 21 (COP 21), the climate conference under the UN Framework Convention on Climate Change (UNFCCC), held at Paris in 2015, represents the historic and main international legally binding reference framework for climate change and related impacts (Rogelj et al. 2016). It thus essentially contributes to and is aligned with the SDGs. All the parties (countries) are committed to the common goal to (1) limit the increase of temperature to under +2 °C by and if at all possible to as low as +1.5 °C (as referred to pre-industrial conditions) by controlling greenhouse gas emissions[5] and (2) reaching the greenhouse gas emission peak as soon as possible, and (3) balance between anthropogenic greenhouse gas emission and removal by sinks in the second half of this century (UNFCCC 2015; Rogelj et al. 2016). Therefore, the course of development during this century is expected to be free of fossil fuels (Obergassel et al. 2016). It focuses on climate resilient development through adaptation of climate change complemented by suitable financial flows (UNFCCC 2015). As part of the policy, individual countries submitted their climate actions for post-2020 and are required to report the progress of emission cuts every five years to UNFCCC under the Intended Nationally

[3] http://www.unisdr.org/2005/mdgs-drr/link-mdg-drr.htm. Accessed on June 1, 2017.

[4] https://sustainabledevelopment.un.org/sdg13. Accessed on June 1, 2017.

[5] http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf. Accessed on June 1, 2017.

Determined Contribution policy (INDC) (UNFCCC 2015) (See Footnote 5)[6].

The Paris Agreement was crucial in view of the fact that major greenhouse gas emitting countries ratified this agreement[7]. So far, of the 197 member countries, 147 have ratified this agreement (see Footnote 6). As part of the agreement, the USA committed to reduce the greenhouse gas emissions by 26–28% from the 2005 levels and the European Union decided to cut the emissions by 40% by 2030 from the 1990 levels (see Footnote 7). However, the commitments in agreement face major challenges since limiting the temperature rise and greenhouse gas emissions to the suggested levels will require substantial efforts on part of the INDCs (Rogelj et al. 2016). Recently, the US government has decided to quit the agreement, representing a serious setback to climate change negotiations. Obergassel et al. (2016) suggest that even if the agreement is fully implemented, the average temperature will still increase by 2.7–3.5 °C. Sincere actions at national, sub-national, and non-state levels are required to meet the global targets agreed at the Paris Agreement (Rogelj et al. 2016).

Present Initiative

The complicated nature and dynamics of impact of disasters probes us for further investigations on microlevel studies and trying to explore the common thread for making policies at the global level. In this context, 19 case studies representing different ecosystems have been presented in two sections of the present volume, viz., (1) evidence of climate change and extreme events and (2) coping with extreme events and disasters, while the introductory Chap. 1 is attempted to explain inter-linkages of climate change, extreme events, and the development of concept of DRR, vulnerability, and hazards. The section on climate change and extreme events covers ten case studies from the study of weather- and climatic-related disasters in high mountains of the world including Hindu-Kush-Himalaya, Andes, European Alps, and mountains of Africa and central Asia, to impacts including vegetation changes, plants activities, food security, and urban environmental hazards induced from rainfall and temperature extremes (floods and droughts).

The Chap. "Analysis of weather- and climate-related disasters in mountain regions using different disaster databases" analyzes weather- and climatic-induced disasters in major mountains of the world. The study uses four disaster databases to analyze weather and climatic disasters in World Mountains. The mountains are globally fragile and are prone to variety of disasters. Though there is insufficient evidence to explain the increasing frequencies of mountain hazards and their linkage to climate change.

The Chap. "Influence of climate change on environmental hazards and human well-being in the urban areas—Warsaw case study versus general problems" assesses the impacts of changing urban landscape and their sensitivity to climate change which is further linked to quality of life. The changing climates of urban areas caused by land use changes have led to the formation of heat island, which has negative implications on the quality of human life. The changed land use patterns and associated changes in local climate will worsen the quality of life especially in case of vulnerable population such as elderly people and children.

The Chap. "Physiographic Influence on Rainfall Variability: A Case study of Upper Ganga Basin" deals with rainfall variability caused by physiographic factor in upper Ganga Basin, India. The study reveals that rainfall variability is high in the pre- and post-monsoon season, whereas monsoon rains show relatively stable rainfall in Ganga Basin. The annual rainfall trend shows no significant changes in study area.

The Chap. "Water Deficit Estimation under Climate Change and Irrigation Conditions in the Fergana Valley, Central Asia" discusses the

[6]http://unfccc.int/paris_agreement/items/9485.php. Accessed on June 1, 2017.

[7]https://www.weforum.org/agenda/2016/09/what-is-the-paris-agreement-on-climate-change/ Accessed on June 1, 2017.

changes in irrigation water deficiency in the Fergana valley of Central Asia under different climate scenarios for 2020, 2050, and 2080 based on future weather patterns developed from Global Circulation Models (GCM). The irrigation water demands are likely to increase in future due to increased Potential Evaporation (PET) caused by an increase in temperatures and changes in precipitation. Similarly, the area under irrigation water deficiency will increase.

Long-term vegetation activity responses to rainfall changes have been studied in Bundelkhand region in the chapter "Long-Term Trend of NDVI Response to Rainfall: A Geo-Spatial Approach." Varying patterns of vegetation trends to rainfall have been found in the study area. Temperature and rainfall variability for the upper Beas basin in western Himalaya were studied using Mann-Kendall and Sen's slope tests in seventh chapter. Significant warming trends and narrowing temperature ranges have been noticed in the study. The rainfall and rainy days have declined in the study area over a period of 1980–2010.

The impacts of extreme weather events on food security were explored in the Chap. "The Impact of Extreme Weather Events on Food Security." Extreme events directly damage agricultural land and hamper the food distribution chain system, especially in urban areas.

The changes in land use patterns of the land affected by sedimentation processes in Gumti River, Tripura, are analyzed in the Chap. "Sedimentation Induced Depositional Lands of the Gumti River of Tripura and its Land Use Pattern." Over the period of time, the sedimentation process in the banks of Gumti River has led to stable depositional land, where many land use/cover types (agricultural, vegetation, settlements, etc.) have emerged over the years.

Vegetation species activity changes as a result of anthropogenic transformations of landscape in Altai Krai are presented in the Chap. "Landscape Changes in the Activity of Higher Altitude Vascular Plants Species in the OB Plateau (Altai Krai, Russia)." As a result, the activity of steppe species decreased in zonal and intrazonal landscapes. The activities of many alien species have increased.

Shallow landslides as a result of rainfall have been attempted to predict in Uttarakhand Himalaya, India, in the Chap. "Application of Classification and Regression Trees for Spatial Prediction of Rainfall Induced Shallow Landslides in the Uttarakhand Area (India) Using GIS," based on Classification and Regression Trees (CART). A landslide inventory has resulted in the identification of 430 historic landslides. Eleven factors that may affect the landslide occurrence (slope angle, aspect, elevation, etc.) were used in the CART model. The results may be helpful in landslide impact reduction in the study area.

The second section of this volume deals with coping with extreme events and disaster case studies. A total of nine case studies are presented in this section, including topics such as droughts, flash floods, future global warming modeling and associated ocean expansion, El Niño, La Niña, and related economic losses to community resilience.

The recurrence of drought events and their impacts on the rural areas of Zimbabwe are analyzed in the Chap. "Is Climate Change the Nemesis of Rural Development?: An Analysis of Patterns and Trends of Zimbabwean Droughts?." Mean temperature and the severity of droughts increased in this study area. It led to losses in agricultural production, crop failures, food insecurity, and erosion of rural livelihoods and vulnerability of rural economies. The study urges for new resilience strategies in Zimbabwe.

The Chap. "Entering the new +2 °C Global Warming Age and a Threat of World Ocean Expansion for Sustainable Economic Development" deals with different temperature rise scenarios and likely sea level rise. It is assessed that if the global average temperature rises beyond 1.3 °C relative to pre-industrial level associated with 9.8 m sea level rise, it may destabilize the Earth's climate system and may further lead to global cooling. Therefore, the mid-century strategies for the transition to low-emission pathways should address this issue before it is too late.

Climate scenario and hydrological models were combined in a GIS environment to examine the rainstorm-led water logging impacts, river floods, and sea level rise in Shanghai, a coastal city in China in the Chap. "Climate change and coastal mega-cities: disaster risk assessment and responses in Shanghai City." Disaster risk assessment, prevention, and adaptation measures are explored along with suitable recommendations for spatial-specific emergency measures to enhance resilience in Shanghai.

Socio-economic impacts of hydro-climatic extreme events caused due to the La Niña event of 2010–2011 in Colombia are examined in the Chap. "La Niña event 2010–2011: hydroclimatic effects and socioeconomic impacts in Colombia." Flashfloods, landslides, and long-term inundations were caused by the La Niña event in 2010–11, which led to many socio-economic tensions. The communities were forced to leave their own regions and move to other regions, where many social conflicts worsened. Learning from this event may serve for strengthening the regional disaster risk management practices.

Taking the case study of Malaysia, the importance of artificial rains in rainfall deficit seasons is discussed in the Chap. "The Experience of Disaster Risk Reduction and Economic Losses Reduction in Malaysia during the Water Crisis 1998 in the Context of the Next El Niño Strongest on Record Maximum 2015." The impact and risk of drought can be effectively minimized through artificial rains during El Niño years.

DRR in mountain agriculture as a result of transformation from traditional agricultural practices to modern agroforestry practices are dealt with in the Chap. "Sustainable disaster risk reduction in mountain agriculture: Agroforestry experiences in Kaule, mid-hills of Nepal." Agroforestry was introduced with proper training of local farmers, which has positive impacts on soil quality and productivity, species richness and diversity, and livelihood security. It further has an impact on risk reduction in the mountain agriculture of Nepal.

The Magisterial community in the Valles urban area in San Luis Potosí, Mexico, has developed and adopted their own strategies to cope with flash floods (The chap. "Building Community Resilience to Flash Floods: Lessons Learnt from a case study in the Valles Urban Area, SLP, Mexico"). Although they are still not a resilient community, fundamental aspects for becoming the resilient community have been well developed.

Quantification of geo-diversity using topographic and climatological characteristics in Sikkim, India, has been done for conservation and DRR research (The Chap. "Quantification of Geodiversity of Sikkim (India) and its Implications for Conservation and Disaster Risk Reduction Research"). A geo-diversity map has been produced which roughly matches the biological richness map of Indian Institute of Remote Sensing (IIRS), India. The geo-diversity map can contribute to conservation of biological diversity in concerned regions.

Five different methods have been used to analyze peak water discharge for flood management in the Lower Gandak Basin, India, in the Chap. "Peak Discharge Analyses for Flood Management in Lower Gandak Basin." The floods are a curse for the people in the Gandak Basin and therefore, flood discharge estimation may contribute to reduction of the impacts of floods by initiating suitable engineering structures in the basin.

Conclusion

The concept of DRR has evolved over the years bringing new horizons based on continuous learning. Climate change-led extreme events have increased in past. In recent years, efforts in DRR also increasingly focused on the reduction of the vulnerability and exposure components, rather than looking mainly on the reduction of the hazard component of risk. Thus, the human components have been increasingly recognized as part of disaster risk reduction. The discourse of DRR is nearly three decade old, starting from IDNDR (1990s) to Paris Climate Agreement in 2015. Significant achievements in case of DRR have been made over the years; the average numbers of causalities per event have decreased.

However, still a lot remains to be done as the vulnerability and exposure to extreme events has also increased. Vulnerable sections of society are at particular risk including poor, disabled, dependent, un-educated, women, and therefore there is a need to focus on people-centric DRR in years to come.

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